# SYLLABUS

## Post Graduate & Ph.D. Programme

## FACULTY OF AGRICUTURE

DIRECTORATE OF EDUCATION
**AGRICULTURE UNIVERSITY, JODHPUR**
JODHPUR - 342304

For office use only

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JODHPUR-342304

**Publication No.: AUJ/2024/02**

**Compiled & Edited by : Dr. Dama Ram**
**(Assistant Director Education)**

**Contributed by : Dr. Sita Ram Kumhar**
**(Dean & Faculty Chairman, HoD GPB)**

**: Dr. Ramdev Sutaliya**
**(HoD, Agronomy)**

**: Dr. J. R. Verma**
**(HoD, Plant Pathology)**

**: Dr. M. M. Sundria**
**(HoD, Entomology)**

**: Dr. R. L. Bhardwaj**
**(HoD, Horticulture)**

**: Dr. Sewa Ram Kumawat**
**(HoD, Extension Education)**

**: Dr. U. N. Shukla**
**(HoD, Soil Science)**

**Published by Dr. Pardeep Pagaria**
**Director Education**
**Agriculture University, Jodhpur**
**Jodhpur- 342304, Rajasthan**
**Email: dreduaujodhpur@gmail.com**

**Dr. Arun Kumar**
**Vice-Chancellor**
**Agriculture University, Jodhpur**
**Email: vcunivag@gmail.com**

# FOREWORD

The Agriculture University, Jodhpur was established on 14th September, 2013 by Government of Rajasthan under Agriculture University, Jodhpur Act 21 of 2013 to focus on holistic development of agricultural education, research and extension in arid and semi-arid regions of Rajasthan. Presently, the University has four Agriculture Colleges at Jodhpur, Sumerpur, Nagaur and Baytu; one College of Dairy and Food Technology, Jodhpur and one College of Tecnology and Agricultural Engineering, Jodhpur to produce highly competent human resource in agriculture and allied sciences.

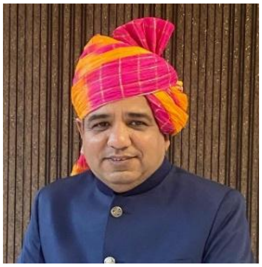
The University offers Master's programme in ten disciplines; Agronomy, Genetics and Plant Breeding, Vegetable Science, Plant Pathology, Entomology, Extension Education, Soil Science, Organic Farming, Fruit Science, Plantation, Spices, Medicinal and Aromatic Crops; Ph.D. Programme in five disciplines *viz.*, Agronomy, Genetics and Plant Breeding, Vegetable Science, Plant Pathology and Entomology. The Broad Subject Matter Area (BSMA) Committees, ICAR, New Delhi has restructured syllabi (2021) of PG and Ph.D. degree programme with the implementation of New Education Policy (NEP) 2020. As per BSMA recommendations, Agriculture University, Jodhpur has revised the course content. After getting approval from statuary bodies, the University has adopted this restructured syllabus in different disciplines for Post Graduate and Ph.D. programme. The booklet **"Syllabus Post Graduate & Ph.D. Programme"** has compiled with semester wise distribution of courses, both theory and practical contents and with suggested relevant reading references. This syllabus will provide opportunities to the students to choose courses to support their planned research activities. The information presented in this booklet is designed to empower PG and Ph.D. students with the knowledge and skills necessary to enhance their employability, foster entrepreneurial capabilities, and prepare them to excel in a globally competitive environment.

This booklet will prove to be useful to the students, teachers and administrators for smooth conduct of Post Graduate and Ph.D. Programme in the faculty of Agriculture. I congratulate the university team for preparing this booklet.

Date: December 20, 2024

Place: Jodhpur

**(Arun Kumar)**



**Dr. Pradeep Pagaria**
**Director Education**
**Agriculture University, Jodhpur**
**Email: dreduaujodhpur@gmail.com**

# Overview

At ICAR level, Broad Subject Matter Area (BSMA) Committees have restructured the syllabi and Academic Regulations for Masters and Ph.D. programmes, defining names and curricula of Masters' and Ph.D. disciplines for uniformity and revised the courses of Masters' and Ph.D. degree programme. As per the recommendations of BSMA, the Agriculture University Jodhpur has constituted committees at Department level under the Chairmanship of concern Departmental Heads to revise the course content. These committees have conducted meetings at Department level with the concerned experts and revised the syllabus for their respective subjects. While revising the syllabi, various provisions of National Education Policy-2020 and modifications as per local requirement have also been considered and by following the spirit of Choice Based Credit System (CBCS), the students are given opportunity to select minor and supporting courses from any discipline/Department enabling the multi-disciplinary approach and to provide quality higher education and to develop thoughtful and smart creative individuals. Necessary provisions have been made in the curricula of eleven disciplines to enable an individual to study major and minor specialized areas of interest at a deep level, and also develop intellectual curiosity, scientific temper and creativity. This restructured syllabus have been duly approved by Board of Studies and subsequently in Academic Council and, the Board of Management for its adoption in the University Department of Agronomy, Plant Breeding and Genetics, Horticulture, Plant Pathology, Entomology, Extension Education, Soil Science at Post Graduate and in five Departments; Agronomy, Genetics and Plant Breeding, Horticulture, Plant Pathology and Entomology at Ph.D. level.

I express my gratefulness to all the Heads of the Departments as Chairmen, under whose guidance the the task of booklet **"Syllabus Post Graduate & Ph.D. Programme"** is completed. I wish to place on record the suggestions and directions shown by all invited Experts of various Departments. During this comprehensive exercise of upgrading the course contents, the much-needed academic support and participation rendered by Deans and Directors is greatly acknowledged. I also appreciate and acknowledge the efforts made by Dr. Dama Ram, Assistant Professor (Plant Pathology) to take up the work of editing, proof reading, finalizing and bringing out **"Syllabus Post Graduate & Ph.D. Programme"** for the Departments of Universityin this shape. The support and help extended by all the faculty members at the University who contributed by their effective participation and interaction is also greatly acknowledged.

Finally,I feel proud privilege to avail the opportunity to express my sincere and deep sense of gratitude to Late Sh. B.R. Choudhary, Former Vice-Chancellor, Agriculture Univesity Jodhpur and to Dr. Arun Kumar, Hon'ble Vice-Chancellor, Agriculture Univesity Jodhpur for their stimulating guidance, constructive suggestions for publication of this booklet.

**(Pradeep Pagaria)**

Date: December 20, 2024
Plae: Jodhpur

**CONTENTS**

# FRAMEWORK OF THE COURSES FOR PG & Ph.D. PROGRAMMES

**Courses and Credit Hours for degree programme in Post-Graduate and Ph.D. disciplines**:

| **Particular(s)** | **Masters' Programme** | **Doctoral Programme** |
|---|---|---|
| **i. ) Course work** | **Credit hours** | **Credit hours** |
| Major courses | 20 | 12 |
| Minor courses | 08 | 06 |
| Supporting courses | 06 | 05 |
| Common courses | 05 | - |
| Seminar | 01 | 02 |
| **ii) Thesis Research** | 30 | 75 |
| **Total** | **70** | **100** |

**Major courses**: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken and given *mark. Detailed courses semesterwise distribution & sylllabus available in respective departments section.

**Minor courses**: From the subjects closely related to a student's major subject. Detailed courses outline available in respective departments section.

**Supporting courses**: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overallcompetence. Based on the requirement, any of the following courses may be opted under the supporting courses.

## Common/ Supporting Courses: PG & Ph.D. Programmes

**Supporting courses Title with Credit load for of M.Sc./Ph.D. Degree programme**

| **Course Code** | **Course Title** | **Credit hours** | **Semester** |
|---|---|---|---|
| STAT-511 | Mathematics for Applied Sciences | 2+0 | I |
| STAT-512 | Statistical Methods for Applied Sciences | 2+1 | I |
| STAT-513 | Data Analysis Using Statistical Packages | 2+1 | I |
| STAT-521 | Experimental Designs | 2+1 | II |
| STAT-522 | Basic Sampling Techniques | 2+1 | II |
| STAT-523 | Applied Regression Analysis | 2+1 | II |

**Common Courses:** The following courses (one credit each) will be offered to all students undergoing Master's degree programme:

**Common courses Title with Credit hrs. (Non-credit): M.Sc./Ph.D. Degree programme**

| **Course No.** | **Course Title** | **Credit hrs.** | **Semester** |
|---|---|---|---|
| PGS 501 | Library and Information Services | 1(0 + 1) | I |
| PGS 502 | Technical Writing and Communications Skills | 1(0 + 1) | I |
| PGS 503 | Intellectual Property and its Management in Agriculture | 1(1 + 0) | I |
| PGS 504 | Basic Concepts in Laboratory Techniques | 1(0 + 1) | II |
| PGS 505 | Agricultural Research, Research Ethics and Rural Development Programme | 1(1 + 0) | II |

# COURSE CONTENTS : SUPPORTING COURSES

## STAT 511 MATHEMATICS FOR APPLIED SCIENCES 2 (2+0)

**AIM OF THE COURSE**

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. The students would get an exposure to Linear Algebra, differentiation, integration and differential equations *etc.*

**THEORY**

**UNIT-I:** Set theory-set operations, finite and infinite sets, operations of set, function.

**UNIT-II:** Vectors and vector spaces, Matrices notations and operations, laws of matrix algebra; transpose and inverse of matrix, Eigen values and Eigen vectors. Determinants – evaluation and properties of determinants, Solutions of Linear Equations.

**UNIT-III:** Variables and functions, limits and continuity of specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, Differentiation of function of a function, derivatives of higher order, partial derivatives. Application of derivatives, determination of points of inflexion, maxima and minima.

**UNIT-IV:** Integration, methods of integration, reduction formulae, definite and indefinite integral, Applications of integration in Agriculture, Differential Equations.

**SUGGESTED READINGS**

1. Hohn FE. 2013. Elementary Matrix Algebra, 3rd Ed., Kindle Edition
2. Harville D.A. 1997. Matrix Algebra from a Statistician's Perspective. Springer.
3. Hohn F.E. 1973. Elementary Matrix Algebra. Macmillan.
4. Searle S.R. 1982. Matrix Algebra Useful for Statistics. John Wiley. Stewart J. 2007. Calculus. Thompson.
5. Thomas G.B. Jr. and Finney R.L. 1996. Calculus. 9th Ed. Pearson Edu.

## STAT 512 STATISTICAL METHODS FOR APPLIED SCIENCES 3 (2+1)

**AIM OF THE COURSE**

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

**THEORY**

**UNIT-I:** Box-plot, Descriptive statistics, Theory of probability, Random variable and mathematical expectation.

**UNIT-II:** Discrete and continuous probability distributions, Binomial, Poisson and Normal distribution their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions.

**UNIT-III:** Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression coefficients, Coefficient of determination, Fitting of quadratic models.

**UNIT-IV:** Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test. Median test.

**UNIT-V:** Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

**PRACTICAL**

- Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal;

- Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F;
- Confidence interval estimation and Correlation and regression analysis, fitting of Linear and Quadratic Model;
- Non-parametric tests. ANOVA: One way, Two Way, SRS.

**SUGGESTED READINGS**


1. Goon, A.M, Gupta, M.K and Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The
2. World Press.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. 1983. Fundamentals of Statistics. Vol. I. The World Press.
4. Hoel, P.G. 1971. Introduction to Mathematical Statistics. John Wiley.
5. Hogg, R.V. and Craig T.T. 1978. Introduction to Mathematical Statistics. Macmillan.
6. Morrison D.F. 1976. Multivariate Statistical Methods. McGraw Hill.
7. Hogg, R. V, McKean J. W, Craig, A. T. 2012. Introduction to Mathematical Statistics 7$^{th}$ Edition.
8. Siegel S., Johan, N. & Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley.
9. Anderson, T. W. 2009. An Introduction to Multivariate Statistical Analysis, 3$^{rd}$ Ed . John Wiley. http://freestatistics.altervista.org/en/learning.php.
   http://www.statsoft.com/textbook/stathome.html


## STAT 513 DATA ANALYSIS USING STATISTICAL PACKAGES 3 (2+1)

**AIM OF THE COURSE**

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students a hands on experience in the analysis of their research data. This course is useful to all disciplines.

**THEORY**

**UNIT-I:** Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

**UNIT-II:** Test for normality; Testing of hypothesis using chi-square, t and F statistics and Z-test.

**UNIT-III:** Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

**UNIT-IV:** Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

**UNIT-V:** Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

**PRACTICAL**

- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data;
- Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, one-way analysis of variance;
- Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components;
- Linear regression, Multiple regression, Regression plots;
- Discriminant analysis - fitting of discriminant functions, identification of important variables;
- Factor analysis. Principal component analysis - obtaining principal component.

**SUGGESTED READINGS**


1. Anderson C.W. and Loynes R.M. 1987. The Teaching of Practical Statistics. John Wiley.
2. Atkinson A.C. 1985. Plots Transformations and Regression. Oxford University Press.

3. Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmount, California.
4. Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall. Chatfield C. 1995.
5. Problem Solving: A Statistician's Guide. Chapman & Hall.
6. Cleveland W.S. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.
7. Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
8. Erickson B.H. and Nosanchuk T.A. 1992. Understanding Data. 2nd Ed. Open University Press, Milton Keynes.
9. Snell E.J. and Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman and Hall.
10. Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.
11. Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, Conn.
12. Velleman PF and Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.
13. Weisberg S. 1985. Applied Linear Regression. John Wiley.
14. Wetherill GB. 1982. Elementary Statistical Methods. Chapman & Hall.
15. Wetherill GB.1986. Regression Analysis with Applications. Chapman & Hall.
16. Cleveland WS. 1994. The Elements of Graphing Data, 2nd Ed., Chapman & Hall http://freestatistics.altervista.org/en/learning.php.
    http://freestatistics.altervista.org/en/stat.php.
    http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
    http://www.stat.sc.edu/~grego/courses/stat706/.
    www.drs.icar.gov.in.

## STAT 521 EXPERIMENTAL DESIGNS 3 (2+1)

**AIM OF THE COURSE**

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of mDesign of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

**THEORY**

**UNIT-I:** Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

**UNIT-II:** Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

**UNIT-III:** Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

**UNIT-IV:** Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

**PRACTICAL**

- Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments;
- Analysis with missing data;
- Split plot and strip plot designs.

**SUGGESTED READINGS**

1. Cochran, W. G and Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
2. Dean, A. M and Voss, D. 1999. Design and Analysis of Experiments. Springer.
3. Montgomery, D. C. 2012. Design and Analysis of Experiments, 8th Ed. John Wiley.

4. Federer, W. T. 1985. Experimental Designs. MacMillan.
5. Fisher, R. A. 1953. Design and Analysis of Experiments. Oliver & Boyd.
6. Nigam, A. K. and Gupta, V. K. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.
7. Pearce, S. C. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley. www.drs.icar.gov.in.

## STAT 522 BASIC SAMPLING TECHNIQUES 3 (2+1)

**AIM OF THE COURSE**

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

**THEORY**

**UNIT-I:** Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

**UNIT-II:** Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

**UNIT-III:** Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

**UNIT-IV:** Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

**PRACTICAL**

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, *etc.*;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling.

**SUGGESTED READINGS**

1. Cochran, W. G. 1977. Sampling Techniques. John Wiley.
2. Murthy, M. N. 1977. Sampling Theory and Methods. 2nd Ed. Statistical Publ. Soc., Calcutta.
3. Singh, D, Singh P and Kumar P. 1982. Handbook on Sampling Methods. IASRI Publ.
4. Sukhatme, P. V, Sukhatme, B. V., Sukhatme, S. and Asok, C. 1984. Sampling Theory of Surveys with Applications. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
5. Cochran, W. G. 2007. Sampling Techniques, 3rd Edition. John Wiley & Sons Publication.

## STAT 523 APPLIED REGRESSION ANALYSIS 3 (2+1)

**AIM OF THE COURSE**

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multi collinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

**THEORY**

**UNIT-I:** Introduction to correlation analysis and its measures, Correlation from grouped data, correlation, Rank correlation, Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

**UNIT-II:** Problem of correlated errors; Auto correlation; Heteroscedastic models, Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multi collinearity, Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

**UNIT-III:** Diagnostic of multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation.

**UNIT-IV:** Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

**PRACTICAL**

- Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses;
- Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection;
- Handling of correlated errors, multi collinearity;
- Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

**SUGGESTED READING**


1. Kleinbaum, D. G, Kupper LL, Nizam A. 2007. Applied Regression Analysis and Other Multivariable Methods (Duxbury Applied) 4th Ed.
2. Draper, N. R. and Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.
3. Ezekiel, M. 1963. Methods of Correlation and Regression Analysis. John Wiley.
4. Koutsoyiannis, A. 1978. Theory of Econometrics. MacMillan.
5. Kutner, M. H., Nachtsheim CJ and Neter J. 2004. Applied Linear Regression Models. 4th Ed. With Student C. D. McGraw Hill.

# CONTENTS OF COMMON COURSES: PG & Ph.D. PROGRAMME

## PGS 501 LIBRARY AND INFORMATION SERVICES 1 (0+1)

**OBJECTIVE**

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines *etc.*) of information search.

**PRACTICAL**

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, *etc.*); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

## PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS 1 (0+1)

**OBJECTIVE**

To equip the students/scholars with skills to write dissertations, research papers, *etc.* To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

**PRACTICAL TECHNICAL WRITING**

Various forms of scientific writings- theses, technical papers, reviews, manuals, *etc.*; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations *etc.*; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article. Communication Skills- Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

**SUGGESTED READINGS**


1. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
2. Collins' Cobuild English Dictionary. 1995.
3. Harper, C., Gordon, H. M. & Walter, J. A. 1970. Technical Writing. 3rd Ed.
4. Holt, R. & Winston Hornby, A. S. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
5. James, H. S. 1994. Handbook for Technical Writing. NTC Business Books.
6. Joseph, G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
7. Mohan, K. 2005. Speaking English Effectively. MacMillan India.
8. Richard, W. S. 1969. Technical Writing.
9. Barnes & Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
10. Abhishek Sethi, J. & Dhamija, P. V. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
11. Wren, P. C. & Martin, H. 2006. High School English Grammar and Composition. S. Chand & Co.

## PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE 1 (1+0)

**OBJECTIVE**

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

**THEORY**

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

**SUGGESTED READINGS**

1. Erbisch, F. H. & Maredia, K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
2. Ganguli, P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. **V**. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
6. Saha, R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.
7. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

## PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES 1 (0+1)

**OBJECTIVE**

To acquaint the students about the basics of commonly used techniques in laboratory.

**PRACTICAL**

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

**SUGGESTED READINGS**

1. Furr, A. K. 2000. CRC Hand Book of Laboratory Safety. CRC Press.
2. Gabb, M. H. & Latchem, W. E. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

## PGS 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES 1 (1+0)

**OBJECTIVE**

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

**THEORY**

**UNIT-I:** History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

**UNIT-II:** Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

**UNIT-III**: Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

**SUGGESTED READINGS**

1. Bhalla, G. S. & Singh, G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia, M. S. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.
3. Rao, B. S. V. 2007. Rural Development Strategies and Role of Institutions- Issues, Innovations and Initiatives. Mittal Publ.
4. Singh, K. 1998. Rural Development- Principles, Policies and Management. Sage Publ.

# DEPARTMENT OF AGRONOMY
# AGRICULTURE UNIVERSITY, JODHPUR

**Semester wise Course Title and Credits : M.Sc. (Agri.) Agronomy**

| S.No. | Course No. | Credit hour | Course title |
|---|---|---|---|
| **Semester-I** | | | |
| 1. | AGRON 511* | 3+0 | Modern concepts in crop production |
| 2. | AGRON 512* | 2+1 | Principles and practices of soil fertility & nutrient management |
| 3. | AGRON 513* | 2+1 | Principles and practices of weed management |
| **Semester-II** | | | |
| 4. | AGRON 521* | 2+1 | Principles and practices of water management |
| 5. | AGRON 522** | 2+1 | Agronomy of major cereals and pulses |
| 6. | AGRON 523# | 1+1 | Conservation agriculture |
| 7. | AGRON 524# | 2 +1 | Agronomy of medicinal, aromatic & underutilized/potential crops |
| 8. | AGRON 525# | 2+1 | Agronomy of fodder and forage crops |
| 9. | AGRON 526# | 2+1 | Agronomy of oilseed, fibre and sugar crops |
| **Semester-III** | | | |
| 10. | AGRON 531# | 2+1 | Dryland farming and watershed management |
| 11. | AGRON 532** | 2+0 | Cropping system and sustainable agriculture |
| 12. | AGRON 533# | 2+1 | Principles and practices of organic farming |
| 13. | AGRON 534# | 2+1 | Agrostology and agro-forestry |
| 14. | AGRON 591 | 1+0 | Master's seminar |
| **Semester-IV** | | | |
| 15. | AGRON 598 | NC | Comprehensive |
| 16. | AGRON 599@ | 30 | Master's research |

[*Core Courses **Compulsory Courses, #Optional Courses as per Advisory/Departmental Committee, NC-Non-Credit Course, @Credit load of Master's Research (AGRON-599) shall be depending upon Advisory committee)].

**Semester wise Course Title and Credits: Ph.D. Agronomy**

| S.No. | Course No. | Course title | Credit hour |
|---|---|---|---|
| **Semester-I** | | | |
| 1. | AGRON 611* | Current trends in agronomy | 3+0 |
| 2. | AGRON 612* | Irrigation management | 2+1 |
| 3. | AGRON 613** | Research and publication ethics | 2+0 |
| 4. | AGRON 614# | Soil conservation and watershed management | 2+1 |
| **Semester-II** | | | |
| 5. | AGRON 691 | Doctor's Seminar | 1+0 |
| 6. | AGRON 621** | Recent trends in weed management | 2+0 |
| 7. | AGRON 622# | Integrated farming systems and sustainable Agriculture | 2+0 |
| 8. | AGRON 623# | Stress crop production | 2+1 |
| 9. | AGRON 624# | Recent trends in crop growth and productivity | 2+1 |
| **Sem-III to Sem-VI** | | | |
| 10. | AGRON 692 | Doctor's Seminar | 1+0 |
| 11. | AGRON 698 | Comprehensive | NC |
| 12. | AGRON 699@ | Doctors research | 75 |

[*Core Courses **Compulsory Courses, #Optional Courses as per Advisory/Departmental Committee, NC=Non-Credit Course, @Credit load of Doctoral Research (AGRON 699) shall be depends upon Advisor and starting of Research Programme of the student in the Degree Programme)].

**Courses requirements: M.Sc. (Agri.) Agronomy and Ph.D. Agronomy**

| Particulars | M.Sc. (Agri.) Agronomy | Ph.D. Agronomy |
|---|---|---|
| Compulsory courses | AGRON 511, AGRON 512, AGRON 513, | AGRON 611, AGRON 612, |

| | | |
|---|---|---|
| (Core and Major) | AGRON 521, AGRON 522, AGRON 532 | AGRON 613, AGRON 621 |
| Optional courses | AGRON 523, AGRON 524, AGRON 525, AGRON 526, AGRON 531, AGRON 533, AGRON 534 | AGRON 614, AGRON 622, AGRON 623, AGRON 624 |
| Minor & supporting Courses* | PP 513, PP 514, PP 523, STAT 512, STAT 521, SSAC 523 | PP 513, PP 514, PP 523, STAT 513, STAT 523 |
| Non-Credit compulsory Courses | AGRON 598, PGS 501, PGS 502, PGS 503, PGS 504 and PGS 505 | AGRON 698, PGS 501, PGS 502, PGS 503, PGS 504, PGS 505 |
| Seminar | AGRON 591 | AGRON 691, AGRON 692 |
| Thesis/Research | AGRON 599 | AGRON 699 |
| Deficiency courses | As deemed suitable by advisory committee, if any. | |

***** Suggested by Advisory Committee.

**Note:** In Ph.D. Programme, PGS Courses (Non-Credit compulsory Courses) shall be compulsory to those students who did not take in their respective Master's Programme.

**Semester wise break-up of credit hours M.Sc. (Agri.) Agronomy & Ph.D. Agronomy**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Non-Credit Compulsory Courses* | Seminar |
|---|---|---|---|---|---|
| **M.Sc. (Ag.) Agronomy** | | | | | |
| I | 3 (9) | 1 (3) | 1 (3) | 3 (3) | - |
| II | 2 (6) | 1 (3) | 1 (3) | 3 (2) | - |
| III | 2 (5) | 1 (3) | - | - | 1 |
| IV | - | - | - | - | - |
| **Ph.D. Agronomy** | | | | | |
| I | 3 (8) | 1 (3) | 1 (3) | - | 1 |
| II | 2 (4) | 1 (3) | 1 (3) | - | 1 |
| III & Onward | **Doctoral Research** | | | | |

***Note:*** No. of credit hours/courses may be increased as per the choice of courses suggested by Advisory Committee of the students.

*PGS Courses (Non-Credit compulsory Courses) shall be compulsory to those students who did not studied in their respective M.Sc. (Agri.) Degree Programme.

**Examination pattern as per BSMA Report:**

| Particulars | Quiz/ Assignment | Mid Term | Final Examination | |
|---|---|---|---|---|
| | | | Theory | Practical |
| Courses with Theory & Practical | 5 | 15 | 50 | 30 |
| Courses with only Theory | 5 | 15 | 80 | - |
| Courses with only Practical | 5 | 15 | - | 80 |

**Pattern of Comprehensive Exam of M.Sc. (Agri.) Agronomy and Ph.D. (Agronomy):**

The pattern will be of Written Exam followed by Oral Exam:

**(i.) Written Exam:**

M.Sc. (Agri.): 2 papers (1 Major + 1 Supporting & Optional subject)
Ph.D.: 3 papers (2 Major + 1 Supporting & Optional subject)
Maximum marks: 100 each
Paper setting: Internal under the Chairmanship of HOD
Evaluation: Internal under the Chairmanship of HOD
Qualifying marks: M.Sc. (Agri.): 60% individually & Ph.D.: 65% individually.

**(ii.) Oral Exam: 100 marks**

M.Sc. (Agri.): After qualifying the Written Exam, the Oral Exam should be conducted by the Students' Advisory Committee in presence of HOD.
Ph.D.: Exam will be conducted by External Examiner
Grading of the Comprehensive Exam (M.Sc. & Ph.D.): Satisfactory/ Not Satisfactory.

# COURSE CONTENTS: M.Sc. (Agri.) AGRONOMY

## AGRON 511 MODERN CONCEPTS IN CROP PRODUCTION 3(3+0)

**OBJECTIVE:** To teach the basic concepts of soil management and crop production.

**COURSE OUTCOME:** The student will learn the basic knowledge on soil management and crop production.

**THEORY**

**UNIT-I:** Crop growth analysis in relation to environment; geo-ecological zones of India.

**UNIT-II:** Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

**UNIT-III:** Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.

**UNIT-IV:** Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition.

**UNIT-V:** Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; Modern crop production concepts: soil less cultivation, Aeroponic, Hydroponic, Robotic, protected agriculture and terrace farming. Precision agriculture: Use of GIS, GPS and remote sensing in modern agriculture.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion

**SUGGESTED READINGS**

1. Alvin, P.T. and Kozlowski, T.T. (eds.) 1976. Ecophysiology of Tropical Crops. Academia Publishers., New York.
2. Balasubramaniyan, P. and Palaniappan, S. P. 2001. Principles and Practices of Agronomy. *Agrobios* (India).
3. Fageria, N. K. 1992. Maximizing Crop Yields. CRC Press.
4. Gardner, P.P., Pearce, G.R. and Mitchell, R. L. 1985. Physiology of Crop Plants. Scientific Publishers. Jodhpur.
5. Havlin, J. L., Beaton, J. D., Tisdale, S.L. and Nelson, W. L. (2005) Soil Fertility and Fertilizers: An Introduction to Nutrient Management. 7th Edition, Pearson Educational, Inc., Upper Saddle River, New Jersey.
6. Lal, R. 1989. Conservation tillage for sustainable agriculture: Tropics versus Temperate Environments. *Advances in Agronomy* **42**: 85-197.
7. Paroda, R. S. 2003. Sustaining our Food Security. Konark Publishers Pvt Ltd.
8. Reddy SR. 2000. Principles of Crop Production. Kalyani Publishers.
9. Sankaran, S. & Mudaliar, T. V. S. 1997. Principles of Agronomy. The Bangalore Printing & Publishing Co. Ltd.
10. Singh, S. S. 2006. Principles and Practices of Agronomy. Kalyani Publishers.
11. Singh, Ummed and Praharaj, C. S. 2021. Nutrient Use Efficiency through Next Generation Fertilizers. Brillion Publishing, New Delhi.
12. Wilsie, C. P. 1961. Crop Adaptation and Distribution. Euresia Publishers., New Delhi.

## AGRON 512 PRINCIPAL AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT 3(2+1)

**OBJECTIVE**

To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

**COURSE OUTCOME:** The student will learn the basic knowledge on soil fertility and management.

**THEORY**

**UNIT-I:** Soil fertility and productivity – factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming – basic concepts and definitions.

**UNIT-II:** Criteria of essentiality of nutrients; essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

**UNIT-III:** Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management.

**UNIT-IV:** Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions; next generation fertilizers *viz*; Nanofertilizers, coated fertilizers, slow-release fertilizers.

**UNIT-V:** Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermicompost and residue wastes in crops.

**PRACTICAL**

1. Soil and plant sampling and processing for chemical analysis;
2. Determination of soil pH and soil EC;
3. Determination of soil organic C;
4. Determination of available N, P, K and S of soil;
5. Determination of total N, P, K and S of soil;
6. Determination of total N, P, K, S in plant;
7. Computation of optimum and economic yield.

**TEACHING METHODS/ACTIVITIES**: Classroom teaching with AV aids, group discussion, assignment and class discussion

**READING MATERIALS**:


1. Brady, N. C. & Weil, R. R. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Education.
2. Fageria, N. K., Baligar, V. C. & Jones, C. A. 1991. Growth and Mineral Nutrition of Field Crops. Marcel Dekker.
3. Havlin, J. L., Beaton, J. D., Tisdale, S. L. & Nelson, W. L. 2006. Soil Fertility and Fertilizers. 7th Ed. Prentice Hall.
4. Prasad, R. & Power, J. F. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press.
5. Singh, Ummed. and Praharaj, C.S. 2017. Chemical Analysis of Soil and Plant Samples. Practical Manual (13/2017), ICAR-Indian Institute of Pulses Research, Kanpur, Uttar Pradesh-208 024, India. pp. 1–58
6. Singh, Ummed. and Praharaj, C.S. 2021. Nutrient Use Efficiency through Next Generation Fertilizers. Brillion Publishing, New Delhi. ISBN: 9789390757749 (Hard Book) e-ISBN: 9789390757756 (eBook)
7. Yawalkar, K. S, Agrawal, J. P & Bokde, S. 2000. Manures and Fertilizers. Agri-Horti Publisher.


## AGRON 513 PRINCIPLES AND PRACTICES OF WEED MANAGEMENT 3(2+1)

**OBJECTIVE**

To familiarize the students about the weeds, herbicides and methods of weed control.

**COURSE OUTCOME:** The student will learn the basic knowledge on weed identification and control for crop production.

**THEORY**

**UNIT-I:** Weed biology, and ecology and classification, crop-weed competition including allelopathy; principles and methods of weed control and management; weed indices, weed shift in different eco-systems.

**UNIT-II:** Herbicides introduction and history of their development; classification based on chemical, physiological, application and selectivity; mode and mechanism of action of herbicides.

**UNIT-III:** Herbicide structure-activity relationship; factors affecting efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides, weed control through use of nano-herbicides and bio-herbicides, myco-herbicides/bioagents, and allelochemicals; movement of herbicides in soil and plant, degradation of herbicides in soil and plants; residue, persistence and management; herbicide resistance, development of herbicide resistance in weeds and crops and their management, herbicide combination and rotation.

**UNIT-IV:** Weed management in major crops and cropping systems; alien, invasive and parasitic weeds and their management; weed shifts in cropping systems; aquatic and perennial weed control; weed control in non-cropped area.

**UNIT-V:** Integrated weed management; recent development in weed management- robotics, use of drones and aeroplanes, organic weed management *etc.*, cost: benefit analysis of weed management.

**PRACTICAL**

1. Identification of important weeds of different crops;
2. Preparation of a weed herbarium;
3. Weed survey in crops and cropping systems;
4. Crop-weed competition studies;
5. Weed indices calculation and interpretation with data;
6. Preparation of spray solutions of herbicides for high and low-volume sprayers;
7. Use of various types of sprayer, pumps and nozzles, and calculation of swath width;
8. Economics of weed control;
9. Herbicide resistance analysis in plant and soil;
10. Bioassay of herbicide resistance/residues;
11. Calculation of herbicide requirements.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, field visit to identify weeds.

**SUGGESTED READINGS**


1. Boger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. Herbicide Classes in Development: Mode of Action, Targets, Genetic Engineering, Chemistry. Springer, Verlag Berlin, Heidelberg.
2. Chauhan Bhagirath and Mahajan Gulshan. 2014. Recent Advances in Weed Management. Springer, New York, NY (DOI: https://doi.org/10.1007/978-1-4939-1019-9).
3. Das, T. K. 2019. Weed Science: Basics and Applications, Jain Brothers, New Delhi (India)
4. Fennimore, Steven A. and Bell, Carl. 2014. Principles of Weed Control, 4th Ed, California Weed Sci. Soc.
5. Gupta, O. P. 2007. Weed Management: Principles and Practices, 2nd Ed.
6. Gupta, O. P. 2015. Weed Management: Principles and Practices (3rd edition), *Agrobios* (India), Jodhpur.
7. Gupta, O. P. 2016. Modern Weed Management (3rd edition), *Agrobios* (India), Jodhpur.
8. Jugulan, Mithila (ed). 2017. Biology, Physiology and Molecular Biology of Weeds. CRC Press.
9. Monaco, T.J., Weller, S. C. and Ashton, F. M. 2002. Weed Science: Principles and Practices. John Wiley and Sons, Inc., New York.
10. Powles, S. B. and Shaner, D. L. 2001. Herbicide Resistance and World Grains, CRC Press.
11. Rao, V. S. 2000. Principals of Weed Science (2nd edition), Oxford and IBH Publishing Co., New Delhi.
12. Saraswat, V. N., Bhan, V. M. and Yaduraju, N. T. 2003. Weed Management, ICAR, New Delhi.
13. Shukla, U.N. 2016. A Practical Manual on Weed Management (Fourth Dean Committee), Department of Agronomy, College of Agriculture, Jodhpur (Publication No.: CoA/MND/02/2016)

14. Shukla, U. N. and Mishra, M. L. 2020. A Practical Manual on Weed Management (Fifth Dean Committee), Department of Agronomy, College of Agriculture, Jodhpur (Publication No.: CoA/JODH/27/2020)
15. Walia, U. S. 2006. Weed Management, Kalyani Publishers, New Delhi.
16. Zimdahl, R. L. (ed). 2018. Integrated Weed Management for Sustainable Agriculture (1st Edition) Burleigh Dodds Science Publishing Limited, 82 High Street, Sawston, Cambridge, CB22 3HJ , UK.

## AGRON 521 PRINCIPLES AND PRACTICES OF WATER MANAGEMENT 3(2+1)

**OBJECTIVE:** To teach the principles of water management and practices to enhance the water productivity.

**COURSE OUTCOME:** The student will know the basic knowledge on water management for optimization of crop yield.

**THEORY**

**UNIT-I:** Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

**UNIT-II:** Field water cycle, water movement in soil and plants; transpiration; soil-water-plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and loses.

**UNIT-III:** Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses; Irrigation efficiency and water use efficiency.

**UNIT-IV:** Water management of crops and cropping systems; Quality of irrigation water and management of saline water for irrigation, water management in problem soils; Crop water requirement estimation of ET and effective rainfall; Automated irrigation system.

**UNIT-V:** Excess of soil water and plant growth; drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

**UNIT-VI:** Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

**UNIT-VII:** Hydroponics.

**UNIT-VIII:** Water management of crops under climate change scenario.

**PRACTICAL**

1. Determination of Field capacity by field method;
2. Determination of Permanent Wilting Point by sunflower pot culture technique;
3. Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus;
4. Determination of Hygroscopic Coefficient;
5. Determination of maximum water holding capacity of soil;
6. Measurement of matric potential using gauge and mercury type tensiometer;
7. Determination of soil-moisture characteristics curves;
8. Determination of saturated hydraulic conductivity by constant and falling head method;
9. Determination of hydraulic conductivity of saturated soil below the water table by auger hole method;
10. Measurement of soil water diffusivity;
11. Estimation of unsaturated hydraulic conductivity;
12. Estimation of upward flux of water using tensiometer and from depth ground water table;
13. Determination of irrigation requirement of crops (calculations);
14. Determination of effective rainfall (calculations);
15. Determination of ET of crops by soil moisture depletion method;
16. Determination of water requirement of crops;

17. Measurement of irrigation water by volume and velocity-area method;
18 Measurement of irrigation water by measuring devices and calculation of irrigation efficiency;
19. Determination of infiltration rate by double ring infiltrometer.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and field visit

**SUGGESTED READINGS**


1. Majumdar, D. K. 2014. Irrigation Water Management: Principles and Practice. PHL Learning private publishers.
2. Mukund Joshi. 2013. A Text Book of Irrigation and Water Management Hardcover, Kalyani publishers.
3. Lenka, D. 1999. Irrigation and Drainage. Kalyani.
4. Michael, A. M. 1978. Irrigation: Theory and Practice. Vikas Publisher.
5. Paliwal, K. V. 1972. Irrigation with Saline Water. IARI Monograph, New Delhi.
6. Panda, S. C. 2003. Principles and Practices of Water Management. Agrobios.
7. Prihar, S. S & Sandhu BS. 1987. Irrigation of Food Crops - Principles and Practices. ICAR.
8. Reddy, S. R. 2000. Principles of Crop Production. Kalyani.
9. Singh Pratap & Maliwal P. L. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech. Publisher.


## AGRON 522 AGRONOMY OF MAJOR CEREALS AND PULSES 3(2+1)

**OBJECTIVE:** To impart knowledge of crop husbandry of cereals and pulse crops.

**COURSE OUTCOME:** The student will know the basic knowledge on cereals and pulse growing in the country.

**THEORY**

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of

**UNIT-I:** *Rabi* cereals: Wheat and Barley.

**UNIT-II:** *Kharif* cereals: Rice, Maize, Sorghum, Pearl millet & other millets.

**UNIT-III:** *Rabi* pulses: Chickpea, Lentil, Fieldpea, Rajmash.

**UNIT-IV:** *Kharif* pulses: Mungbean, Black gram, Mothbean, Clusterbean, Cowpea.

**PRACTICAL**

1. Phenological studies at different growth stages of crop;
2. Estimation of crop yield on the basis of yield attributes;
3. Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities;
4. Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW *etc.*);
5. Assessment of land use and yield advantage (Diversity Index, Sustainable Yield Index, Crop Equivalent Yield, Land Equivalent Ration, Aggressivity, Relative Crowding Coefficient, Competition Ratio and ATER *etc.*);
6. Estimation of protein content in pulses;
7. Planning and layout of field experiments;
8. Judging of physiological maturity in different crops;
9. Intercultural operations in different crops;
10. Determination of cost of cultivation of different crops;
11. Working out harvest index of various crops;
12. Study of seed production techniques in selected crops;
13. Visit of field experiments on cultural, fertilizer, weed control and water management aspects;
14. Visit to nearby villages for identification of constraints in crop production.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion.

**SUGGESTED READINGS**


1. Jain, L. K. 2020. A Manual on Crop Production Technology (Kharif and Rabi): Bhavya Books, New Delhi. Pp. 1-304.
2. Panda, S. C. 2012. Modern Concepts and Advance Principles in Crop Production. *Agrobios* (India), Jodhpur.
3. Prasad, Rajendra. 2002. Text Book of Field Crops Production. Volume- **I** & **II**. ICAR, New Delhi.
4. Rathore, P. S. 2000. Techniques and Management of Field Crop Production. *Agrobios* (India), Jodhpur.
5. Reddy, S. R. and Ramu, Y. R. 2016. Agronomy of Field Crops. Kalyani Publishers, New Delhi.
6. Shukla, U. N. 2017. A Practical Manual on Field Crops-II (Rabi) (CoA/MND/05/2017). Deptt. of Agronomy, College of Agriculture, Jodhpur.
7. Singh, Chhidda, Singh, P. and Singh, R. 2003. Modern Techniques of Raising Field Crops, Oxford & IBH Publishing Co., New Delhi.
8. Singh, S. S. and Singh, R. 2013. Crop Management Under Irrigated and Rainfed Conditions. Kalyani Publishers, New Delhi.
9. Singh, S. S. and Singh, R. 2015. Principles and Practices of Agronomy. (5th Re-set). Kalyani Publishers, New Delhi.


| **AGRON 523** | **CONSERVATION AGRICULTURE** | **2(1+1)** |
|---|---|---|

**OBJECTIVE:** To impart knowledge of conservation of agriculture for economic development.

**COURSE OUTCOME:** The student will be able to hav the knowledge of various types of conservation of agriculture.

**THEORY**

**UNIT-I:** Conventional and conservation agriculture systems, sustainability concerns, conservation agriculture: Historical background and present concept, Principles of conservation agriculture, Concept of No-till farming, global experiences, present status in India

**UNIT-II:** Nutrient management in CA, water management, weed management, energy use, insect-pest and disease management, farm machinery, crop residue management, cover crop management, crop rotation and intercropping

**UNIT-III:** Climate change adaptation and mitigation strategies, Climate smart agriculture and climate resilient agriculture technologies, C-sequestration, soil health management, soil microbes and CA

**UNIT-IV:** CA in agroforestry systems, rainfed / dryland regions

**UNIT-V:** Economic considerations in CA, adoption and constraints, CA: The future of agriculture

**PRACTICAL**

1. Study of long-term experiments on CA;
2. Evaluation of soil health parameters;
3. Estimation of C-sequestration;
4. Identify different no-tillage implements and their uses;
5. Machinery calibration for sowing different crops;
6. Weed seed bank estimation under CA;
7. Energy requirements and economic analysis of CA;
8. Students should be introduced to the fundamentals of sustainable agricultural practices and Investigate how the intensification of agricultural practices can impact on rural landscapes and the wider environment;
9. Students should be exposed to the farming practices of subsistence communities;
10. Investigate the threats posed by invasive pest species to biodiversity and the livelihoods of subsistence farming communities and;
11. Study the impacts of sustainable harvesting practices on biodiversity.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**LEARNING OUTCOME:** Experience on the knowledge of various types of conservation of agriculture.

**SUGGESTED READINGS**


1. Muhammad, F. and Kamdambot, H.M.S. (2014). Conservation Agriculture. Publisher: Springer Cham Heidelberg, New Yaork Dordrecht London. Doi:10.1007/978-3-319-11620-4.
2. Bisht, J. K., Meena, V.S., Mishra, P.K. and Pattanayak, A. (2016). Conservation Agriculture-An approach to combat climate change in Indian Himalaya. Publisher: Springer Nature. Doi: 10/1007/978-981-10-2558-7.
3. Gracia-Torres, L., Benites, J., Martinez-Vilela, A. and Holgado-Cabera, A. (2003). Conservation Agriculture- Environment Farmers experiences, innovations Socioeconomic policy.
4. Arakeri, H. R & Roy, D. 1984. Principles of Soil Conservation and Water Management. Oxford & IBH.
5. Dhruvanarayana, V. V. 1993. Soil and Water Conservation Research in India. ICAR.
6. FAO. 2004. Soil and Water Conservation in Semi-Arid Areas. Soils Bull., Paper 57.
7. Yellamanda Reddy T. & Sankara Reddy GH. 1992. Principles of *Agronomy*. Kalyani.
8. Jat, M. L. *et al*. (eds) *Proc. Regional Dialogue on Conservation Agriculture in South Asia* (CIMMYT; APAARI; ICAR, 2012).
9. Gonzalez-Sanchez., *et al*., (2017). Conservation agriculture: making climate change mitigation and adaptation real in Europe. European Conservation Agriculture Federation (ECAF).


## AGRON 524 AGRONOMY OF MEDICINAL, AROMATIC AND UNDER UTILIZED/POTENTIAL CROPS 3 (2+1)

**OBJECTIVE:** To acquaint students about different medicinal, aromatic and underutilized/ potential field crops and their package of practices for cultivation and processing.

**COURSE OUTCOME:** The student will be acquainted with various MAP and their commercial base for developing entrepreneurship.

**THEORY**

**UNIT-I:** Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge.

**UNIT-II:** Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Mulhati, Isabgol, Rauwolfia, Poppy, Aloe vera, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, Nuxvomica, Rosadle *etc*.).

**UNIT-III:** Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium).

**UNIT-IV:** Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, Sesbania, French bean, Grain Amaranth, Chia, Quinoa, Asalia, Chamomile, Coffee, Tea).

**UNIT-V:** Post harvest handling–drawing, processing, grading, packing and storage, value addition and quality standards in herbal products.

**PRACTICAL**

1. Identification of medicinal, aromatic and underutilized/ potential crops based on morphological and seed characteristics;
2. Raising of herbarium of medicinal, aromatic and under-utilized plants;
3. Quality characters in medicinal and aromatic plants;
4. Methods of analysis of essential oil and other quality constituents in medicinal and aromatic plants.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and field visit

**LEARNING OUTCOME:** acquainted with various MAP and their commercial base for developing entrepreneurship.

**SUGGESTED READINGS**


1. Chadha, K. L. & Gupta, R. 1995. Advances in Horticulture. Vol. **II**. Medicinal and Aromatic Plants. Malhotra Publ.
2. Das, N. R. 2007. Introduction to Crops of India. Scientific Publ.
3. Handa, S. S. 1984. Cultivation and Utilization of Medicinal Plants. RRL, CSIR, Jammu.
4. Hussain, A. 1984. Essential Oil Plants and their Cultivation. CIMAP, Lucknow.
5. Hussain, A. 1993. Medicinal Plants and their Cultivation. CIMAP, Lucknow.
6. ICAR 2006. Hand Book of Agriculture. ICAR, New Delhi.
7. Kumar, N, Khader, Md. Abdul, Rangaswami JBM & Irulappan 1997. Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants. Oxford & IBH.
8. Prajapati, N. D., Purohit, S. S., Sharma, A. K. & Kumar, T. 2003. A Hand Book of Medicinal Plants: A Complete Source Book. *Agrobios*.
9. Sharma, R. 2004. Agro-Techniques of Medicinal Plants. Daya Publ. House.


## AGRON 525 AGRONOMY OF FODDER AND FORAGE CROPS 3(2+1)

**OBJECTIVE:** To teach the crop husbandry of different forage and fodder crops along with their processing.

**COURSE OUTCOME:** The student will be acquainted with various fodder and forage crops and their commercial base for developing entrepreneurship.

**THEORY**

**UNIT-I:** Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like sorghum, maize, bajra, guar, cowpea, oats, barley, berseem, senji, lucerne, fodder beet root *etc*.

**UNIT-II:** Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasses, Napier grass, *Panicum, Lasiuras, Cenchrus etc*.

**UNIT-III:** Year-round fodder production and management, preservation and utilization of forage and pasture crops.

**UNIT-IV:** Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder. Fodder production through hydroponics. *Azolla* cultivation.

**UNIT-V:** Economics of forage cultivation uses and seed production techniques of important fodder crops.

**PRACTICAL**

1. Practical training of farm operations in raising fodder crops;
2. Canopy measurement, yield, Leaf: Stem ratio and quality estimation, viz. crude protein, NDF, ADF, lignin, silica, cellulose and IVDMD *etc*. of various fodder and forage crops;
3. Anti-quality components like HCN in sorghum and such factors in other crops;
4. Hay and silage making and economics of their preparation.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and field visit

**SUGGESTED READINGS**


1. Chatterjee, B. N. 1989. Forage Crop Production - Principles and Practices. Oxford & IBH.
2. Das, N. R. 2007. Introduction to Crops of India. Scientific Publ.
3. Reddy, D. V. 2014 Fodder production and grassland management
4. Narayanan, T. R. & Dabadghao, P. M. 1972. Forage Crops of India. ICAR.
5. Panda, S. C. 2014. Agronomy of fodder and forage crops
6. Singh, P. & Srivastava, A. K. 1990. Forage Production Technology. IGFRI, Jhansi.
7. Singh, C., Singh,P. & Singh,R. 2003. Modern Techniques of Raising Field Crops. Oxford & IBH.
8. Tejwani, K. G. 1994. Agroforestry in India. Oxford & IBH.

## AGRON 526 AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS 3 (2+1)

**OBJECTIVE:** To teach the crop husbandry of oilseed, fibre and sugar crops

**COURSE OUTCOME:** The student will have the basic knowledge on production of oilseed, fibre and sugar crops.

**THEORY**

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing of the produce for maximum production of:

**UNIT-I:** Rabi oilseeds – Rapeseed and mustard, Linseed and Niger

**UNIT-II:** Kharif oilseeds – Groundnut, Sesame, Castor, Sunflower, Soybean and Safflower

**UNIT-III:** Fibre crops – Cotton, Jute, Ramie, Mesta and Sunhemp.

**UNIT-IV:** Sugar crops – Sugar-beet and Sugarcane.

**PRACTICAL**

1. Planning and layout of field experiments;
2. Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane;
3. Determination of cane maturity and calculation on purity percentage, recovery percentage, sucrose content in cane juice and phenological studies at different growth stages of crop;
4. Intercultural operations in oilseed, fibre and sugar crops;
5. Cotton seed treatment;
6. Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW *etc.*);
7. Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER *etc.*);
8. Judging of physiological maturity in oilseed, fibre and sugar crops and working out harvest index;
9. Working out cost of cultivation of oilseed, fibre and sugar crops;
10. Estimation of crop yield on the basis of yield attributes;
11. Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities;
12. Determination of oil content in oilseeds and computation of oil yield;
13. Estimation of quality of fibre of different fibre crops;
14. Study of seed production techniques in oilseed, fibre and sugar crops;
15. Visit of field experiments on cultural, fertilizer, weed control and water management aspects;
16. Visit to nearby villages for identification of constraints in crop production.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion

**SUGGESTED READINGS**


1. Das, N. R. 2007. Introduction to Crops of India. Scientific Publisher.
2. Das, P. C. 1997. Oilseed Crops of India. Kalyani Publisher.
3. Jain, L. K. 2021. A manual on Crop Production Technology (Kharif and Rabi). Bhavya Books (BET)™.
4. Lakshmikantam, N. 1983. Technology in Sugarcane Growing. 2nd Ed. Oxford & IBH.
5. Prasad, R. 2002. Text Book of Field Crop Production. ICAR.
6. Shukla, U. N. and Mehriya, M. L.2020. Practical Manual on Agronomy of Oilseed, Fibre and Sugar Crops (CoA/JODH/30/2020). Deptt. of Agronomy, College of Agriculture, Jodhpur
7. Singh, C, Singh, P. & Singh, R. 2003. Modern Techniques of Raising Field Crops. Oxford & IBH.
8. Singh, S. S. 1998. Crop Management. Kalyani Publishers.

## AGRON 531 DRYLAND FARMING AND WATERSHED MANAGEMENT 3 (2+1)

**OBJECTIVE**

To teach the basic concepts and practices of dry land farming and soil moisture conservation.

**COURSE OUTCOME:** The student will have the basic knowledge on dry land farming and soil moisture conservation.

**THEORY**

**UNIT-I:** Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture.

**UNIT-II:** Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

**UNIT-III:** Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; contingent plan for aberrant weather conditions.

**UNIT-IV:** Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); anti-transpirants; soil and crop management techniques, seeding and efficient fertilizer use.

**UNIT-V:** Concept of watershed resource management, problems, approach and components.

**PRACTICAL**

1. Methods of seed priming;
2. Determination of germination percent of important dryland crops;
3. Determination of relative water content and saturation deficit of leaf;
4. Moisture stress effects and recovery behaviour of important crops;
5. Estimation of Potential ET by Thornthwaite method;
6. Estimation of Reference ET by Penman Monteith Method;
7. Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index);
8. Classification of climate by Koppen Method;
9. Estimation of water balance by Thornthwaite method;
10. Estimation of water balance by FAO method;
11. Assessment of drought;
12. Estimation of length of growing period;
13. Estimation of probability of rain and crop planning for different drought condition;
14. Spray of anti-transpirants and their effect on crops;
15. Rain water use efficiency;
16. Visit to dryland research stations and watershed projects.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment.

**SUGGESTED READINGS**

1. Das, N.R. 2007. Tillage and Crop Production. Scientific Publ.
2. Dhopte, A.M. 2002. Agrotechnology for Dryland Farming. Scientific Publ.
3. Dhruv Narayan, V.V. 2002. Soil and Water Conservation Research in India, ICAR.
4. Gupta, U. S. (Ed.). 1995. Production and Improvements of Crops for Drylands. Oxford & IBH.
5. Jain, L. K. 2020. Practical Manual on Rainfed Farming and Watershed Management. Agriculture University, Jodhpur
6. Katyal, J. C & Farrington J. 1995. Research for Rainfed Farming. CRIDA.
7. Rao, S. C & Ryan J. 2007. Challenges and Strategies of Dryland Agriculture. Scientific Publ.
8. Reddy, T. Y.2018. Dryland Agriculture Principles & Practices, Kalyani publishers
9. Shukla, U. N. 2016. A Teaching Manual on Rainfed Farming. Department of Agronomy, College of Agriculture, Agriculture University, Jodhpur (CoA/MND/01/2016).
10. Singh, P. & Maliwal P.L. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ. Company.

11. Singh, R. P.1988. Improved Agronomic Practices for Dryland Crops. CRIDA.
12. Singh, R. P.2005. Sustainable Development of Dryland Agriculture in India. Scientific Publ.
13. Singh, S. D.1998. Arid Land Irrigation and Ecological Management. Scientific Publ.
14. Venkateshwarlu, J. 2004. Rainfed Agriculture in India. Research and Development Scenario, ICAR.

## AGRON 532 CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE 2 (2+0)

**OBJECTIVE:**

To acquaint the students about prevailing cropping systems in the country and practices to improve their productivity.

**COURSE OUTCOME:** The student will have the basic knowledge on cropping system for sustainable agriculture.

**THEORY**

**UNIT-I:** Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

**UNIT-II:** Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.

**UNIT-III:** Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of nonmonetary inputs and low cost technologies; research need on sustainable agriculture.

**UNIT-IV:** Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system. Advanced nutritional tools for big data analysis and interpretation.

**UNIT-V:** Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

**UNIT-VI:** Artificial Intelligence- Concept and application.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment.

**SUGGESTED READINGS**

1. Panda, S. C. 2017. Cropping systems and sustainable agriculture. Agrobios (India)
2. Panda, S. C. 2018. Cropping and farming systems. Agrobios.
3. Palaniappan, S. P. & Sivaraman, K. 1996. Cropping Systems in the Tropics; Principles and Management. New Age.
4. Panda, S. C. 2003. Cropping and Farming Systems. Agrobios.
5. Reddy, S. R. 2000. Principles of Crop Production. Kalyani.
6. Sankaran, S. & Mudaliar, T.V.S. 1997. Principles of Agronomy. Bangalore Printing & Publ. Co.
7. Singh, S. S. 2006. Principles and Practices of Agronomy. Kalyani.
8. Tisdale, S. L, Nelson, W. L, Beaton, J. D & Havlin, J. L. 1997. Soil Fertility and Fertilizers. Prentice Hall.

## AGRON 533 PRINCIPLES AND PRACTICES OF ORGANIC FARMING 3 (2+1)

**OBJECTIVE:**

To study the principles and practices of organic farming for sustainable crop production.

**COURSE OUTCOME:** The student will have the basic knowledge on organic farming for sustainable agriculture and development of entrepreneurship on organic inputs.

**THEORY**

**UNIT-I:** Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; principles of organic agriculture; organics and farming standards; organic farming and sustainable agriculture; selection and conversion of land, soil and water management, land use strategy - use of conservation tillage; allocation of land in shelter zones, hedges, pasture management & agro-forestry.

**UNIT-II:** Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues - use of waste decomposer, earthworms and vermicompost, green manures, bio-fertilizers and biogas technology.

**UNIT-III:** Farming systems, selection of crops and crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

**UNIT-IV:** Control of weeds, diseases and insect pest management, biological agents and pheromones, bio-pesticides and ITKs in organic farming management

**UNIT-V:** Socio-economic impacts; marketing and export potential: registration, inspection, certification, labeling and accreditation procedures.

**PRACTICAL**

1. Methods of making compost by aerobic method;
2. Methods of making compost by anaerobic method;
3. Methods of making vermicompost;
4. Method of preparing Jivamrita, Panchgavya and other low cost organic inputs for plant protection;
5. Identification and nursery raising of important agro-forestry trees, trees for shelter belts and plants for biopesticides (*Leucas, Lantana, Datura, Calotropis, Vitex, Pongamia, Jatropha, Adhatoda & Neem);*
6. Efficient use of biofertilizers, technique of treating legume seeds with *Rhizobium* cultures, use of *Azotobacter, Azospirillum*, and *PSB* cultures in field;
7. Visit to a biogas plant;
8. Visit to an organic farm;
9. Quality standards, registration, inspection, certification and labeling and accreditation procedures for farm produce from organic farms.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment, exposure visit

**SUGGESTED READINGS**


1. Joshi, M. 2016. New Vistas of Organic Farming. Scientific Publishers.
2. Ananthakrishnan, T. N. (Ed.). 1992. Emerging Trends in Biological Control of Phytophagous Insects. Oxford & IBH.
3. Gaur, A. C. 1982. A Manual of Rural Composting, FAO/UNDP Regional Project Document, FAO.
4. Lampin, N. 1990. Organic Farming. Press Books, lpswitch, UK.
5. Palaniappan, S. P & Anandurai, K. 1999. Organic Farming – Theory and Practice. Scientific Publ.
6. Rao, B. and Venkata, V. 1995. Small Farmer Focused Integrated Rural Development: Socioeconomic Environment and Legal Perspective: Publ.3, Parisaraprajna Parishtana, Bangalore.
7. Reddy, M. V. (Ed.). 1995. Soil Organisms and Litter Decomposition in the Tropics. Oxford & IBH.
8. Sharma, A. 2002. Hand Book of Organic Farming. *Agrobios*.
9. Singh SP. (Ed.) 1994. Technology for Production of Natural Enemies. PDBC, Bangalore.
10. Subba Rao, N. S. 2002. Soil Microbiology. Oxford & IBH.
11. Trivedi, R. N.1993. A Text Book of Environmental Sciences, Anmol Publ.
12. Veeresh, G. K., Shivashankar, K. & Suiglachar, M. A. 1997. Organic Farming and Sustainable Agriculture. Association for Promotion of Organic Farming, Bangalore.
13. WHO. 1990. Public Health Impact of Pesticides Used in Agriculture. WHO.
14. Woolmer, P. L. & Swift, M. J. 1994. The Biological Management of Tropical Soil Fertility. TSBF & Wiley.

## AGRON 534 AGROSTOLOGY AND AGRO-FORESTRY 3 (2+1)

**OBJECTIVE**

To teach crop husbandry of different forage, fodder and agroforestry crops/trees along with their processing.

**COURSE OUTCOME:** The sudent will know the basic knowledge on agro forestry, forage crops and their utility.

**THEORY**

**UNIT-I:** Agrostology: definition and importance; principles of grassland ecology: grassland ecology – community, climax, dominant species, succession, biotype, ecological status of grasslands in India, grass cover of India; problems and management of grasslands.

**UNIT-II:** Importance, classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses.

**UNIT-III:** Agroforestry: definition and importance; agro-forestory systems, agri-silviculture, silvipasture, agri-silvipasture, agri-horticulture, aqua-silviculture, alley cropping and energy plantation.

**UNIT-IV:** Crop production technology in agro-forestory and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation and manuring in agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in agro-forestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

**PRACTICAL**

1. Preparation of charts and maps of India showing different types of pastures and agro-forestry systems;
2. Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry;
3. Seed treatment for better germination of farm vegetation;
4. Methods of propagation/planting of grasses and trees in silvipastoral system;
5. Fertilizer application in strip and silvipastroal systems;
6. After-care of plantation;
7. Estimation of protein content in loppings of important fodder trees;
8. Estimation of calorie value of wood of important fuel trees;
9. Estimation of total biomass and fuel wood;
10. Economics of agro-forestry;
11. Visit to important agro-forestry research stations.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and field visit

**SUGGESTED READINGS**

1. Chatterjee, B. N. & Das, P. K. 1989. Forage Crop Production. Principles and Practices. Oxford & IBH.
2. Dabadghao, P. M. & Shankaranarayan, K. A. 1973. The Grass Cover in India. ICAR.
3. Dwivedi, A. P. 1992. Agroforestry- Principles and Practices. Oxford & IBH.
4. Indian Society of Agronomy. 1989. Agroforestry System in India. Research and Development, New Delhi.
5. Narayan, T. R. & Dabadghao, P. M. 1972. Forage Crop of India. ICAR, New Delhi.

# COURSE CONTENTS: Ph.D. AGRONOMY

| AGRON 611 | CURRENT TRENDS IN AGRONOMY | 3 (3+0) |
|---|---|---|

**OBJECTIVE:**
To acquaint the students about recent advances in agricultural production.

**COURSE OUTCOME:** Student lean recent advances in agricultural production.

**THEORY:**

**UNIT-I:** Agro-physiological basis of variation in yield, recent advances in soil-plant-water relationship; GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production *etc.*

**UNIT-II:** Globalization of agriculture and WTO, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures and ITK in organic farming; Basics of biofortification and its role in mitigating hidden hunger and malnutrition

**UNIT-III:** Crop residue management in multiple cropping systems; latest developments in plant management, cropping systems, grassland management, agro-forestry, weed management, allelopathy.

**UNIT-IV:** Precision agriculture; mechanization in crop production; modern agricultural precision tools and technologies, GIS, GPS, Regenerative Agriculture and Climate Resilient Agriculture and remote sensing for crop management.

**UNIT-V:** Concepts of system agriculture; holistic approach of farming systems, advances in dryland farming, sustainable agriculture, research methodologies in Agronomy. Conservation agriculture, principles, prospects and importance, potential benefits of CA under climate change scenario, global warming, policy issues.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Agarwal, R.L. 1995. Seed Technology. Oxford & IBH.
2. Dahiya, B.S & Rai, K.N. 1997. Seed Technology. Kalyani.
3. Govardhan, V. 2000. Remote Sensing and Water Management in Command Areas: Agro-ecological Prospectives. IBDC.
4. Gururajan, B. Balasubhramanian, R. and Swaminath V. 2013. Recent Strategies on Crop Production. Kalyani Publishers.
5. ICAR. 2006. Hand Book of Agriculture. ICAR.
6. Kumar, Rajeev, Swarnkar Kumar Sushil, Singh Kumar Sunil and Narayan Sumati. 2016. A Text Book of Seed Technology. Kalyani Publication.
7. Narasaiah, M.L. 2004. World Trade Organization and Agriculture. Sonali Publ.
8. Palaniappan S.P & Annadurai K. 2006. Organic Farming - Theory and Practice. Scientific Publ.
9. Reddy, S.R. and Prabhakara, G. 2015. Dryland Agriculture. Kalyani Publishers.
10. Sen, S. & Ghosh, N. 1999. Seed Science and Technology. Kalyani.
11. Singh, Ummed, Praharaj, C.S., Singh, S.S. and Singh, N.P. 2016. Biofortification of Food Crops. Springer (India) Pvt. Ltd. ISBN 978-81-322-2714-4, ISBN 978-81-322-2716-8 (eBook).
12. Tarafdar, J.C, Tripathi KP & Mahesh Kumar 2007. Organic Agriculture Scientific Publ.
13. Venkateswarlu, B. and Shanker Arun, K. 2009. Climate change and agriculture: Adaptation and mitigation strategies. Indian journal of Agronomy 54(2): 226-230.

| AGRON 612 | IRRIGATION MANAGEMENT | 3(2+1) |
|---|---|---|

**OBJECTIVE:**
To teach students about optimization of irrigation in different crops under variable agro climatic conditions.

**COURSE OUTCOME:** Student can be able to know management of irrigation water for sustainable agriculture.

**THEORY:**

**UNIT-I:** Global water resources; Water resources of India, irrigation projects during pre and post-independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

**UNIT-II:** Water movement under saturated and unsaturated conditions, Poiseulle's and Darcy's law, general equation of saturated and unsaturated flow of water in soil; Soil-plant-water relationships, evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

**UNIT-III:** Water requirement, water use efficiency, management practices for improving water use efficiency of crops.

**UNIT-IV:** Soil and plant water potential, SPAC; Infiltration.

**UNIT-V:** Crop water stress– water deficits and crop growth, adoptability to the crops; water availability with relation to nutrient availability.

**UNIT-VI:** Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

**UNIT-VII:** Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

**UNIT-VIII:** Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation.

**UNIT-IX:** Economic analysis of irrigation and cop planning for optimum use of irrigation water

**UNIT-X:** Crop water production function

**PRACTICAL**

1. Determination of water infiltration characteristics and water holding capacity of soil profiles;
2. Determination moisture extraction pattern of crops;
3. Determination of water balance component of transplanted rice by drum culture technique;
4. Determination of consumptive use and water requirement of a given cropping pattern;
5. Determination of crop efficient of one important crop;
6. Planning, designing and installation of drip irrigation system;
7. Planning, designing and installation of sprinkler irrigation system;
8. Designing of drainage channel;
9. Measurement of irrigation efficiencies;
10. Determination of irrigation timing under different methods of irrigation;
11. Visit to irrigation command area.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Singh, M. P. (2017). Recent advances in Irrigation water management. Kalyani Publishers
2. FAO. 1984. Irrigation Practice and Water Management. Oxford & IBH.
3. Michael, A. M. 1978. Irrigation: Theory and Practice. Vikas Publisher.
4. Mishra, R. R. & Ahmad M. 1987. Manual on Irrigation and Agronomy. Oxford & IBH.
5. Panda, S. C. 2003. Principles and Practices of Water Management. Agrobios.
6. Reddy, S. R. 2000. Principles of Crop Production. Kalyani Publisher.
7. Sankara Reddy, G. H. & Yellamananda, R. 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH.
8. Singh, S. S. 2006. Principles and Practices of Agronomy. Oxford & IBH.

## AGRON 613 RESEARCH AND PUBLICATION ETHICS 2 (2+0)

**OBJECTIVES:**

To study the philosophy of ethics, scientific conduct of research and the publication ethics**.** To know about various journal citation databases**.** To know the importance of quality publications

**COURSE OUTCOME:** The course will develop skill for research management, quality publication and to learn about the scientific misconducts.

**THEORY:**

**UNIT-I:** Introduction to philosophy: definition, nature and scope, concept, branches

**UNIT-II:** Ethics: definition, moral philosophy, nature of moral judgments and reactions

**UNIT-III:** Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

**UNIT-IV:** Publication ethics: Definition, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME *etc*., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals

**UNIT-V:** Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self-archiving policies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools viz, JANE, Elsevier Journal Finder, Springer Journal Suggester *etc*.

**UNIT-VI:** Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools

**UNIT-VII:** Database and Research metrics: Indexing data base, citation database, web of science, scopus *etc*. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, g-index, i 10 index, altmetrics

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, field practicals and laboratory visit.

**SUGGESTED READINGS**

1. Bird, A. 2006. Philosophy of Science, Routledge
2. Chaddah, P. 2018. Ethics in Competitive Research: Do not get scooped; do not get plagiarised.
3. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance 2019.
4. Beall, J. 2012. Predatory publishers are corrupting open access. *Nature*, 489(7415), 179.
5. National Academy of Sciences, National Academy of Engineering and Institute of Medicine (2009). On being a Scientist: A guide to Responsible Conduct in Research, Third Edition, National Academic Press.

## AGRON 614 SOIL CONSERVATION AND WATERSHED MANAGEMENT 3 (2+1)

**OBJECTIVE:**

To teach about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

**COURSE OUTCOME:** Student will have experience on the knowledge of soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

**THEORY:**

**UNIT-I:** Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion.

**UNIT-II:** Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; mulching, tillage, cropping system vegetative barriers; improved dry farming practices; mechanical measures-bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

**UNIT-III:** Watershed management: definition, objectives, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.

**UNIT-IV:** Land use capability classification, alternate land use systems; agroforestry; ley farming; jhum management - basic concepts, socio-ethnic aspects, its layout.

**UNIT-V:** Drainage, methods of drainage, Drainage considerations and agronomic management; rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion.

**PRACTICAL**

1. Study of different types of erosion;
2. Determination of dispersion ratio;
3. Estimation of soil loss by Universal Soil Loss Equation;
4. Estimation of soil loss by wind erosion;
5. Measurement of runoff and soil loss;
6. Field studies of different soil conservation measures;
7. Laying out run-off plot and deciding treatments;
8. Identification of different grasses and trees for soil conservation;
9. Visit to watershed areas;
10. Visit to a soil conservation research centre, demonstration and training centre.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Arakeri, H. R. & Roy, D. 1984. Principles of Soil Conservation and Water Management. Oxford & IBH.
2. Dhruvanarayana, V.V. 1993. Soil and Water Conservation Research in India. ICAR.
3. FAO. 2004. Soil and Water Conservation in Semi-Arid Areas. Soils Bull., Paper 57.
4. Frederick, R. T., Hobbs, J., Arthur, D. & Roy, L. 1999. Soil and Water Conservation: Productivity and Environment Protection. 3rd Ed. Prentice Hall.
5. Singh, G., Venkataraman, C. G., Sastry, B. & Joshi, P. 1990. Manual of Soil and Water Conservation Practices. Oxford & IBH.
6. Murthy, V.V.N. 1995. Land and Water Management Engineering. Kalyani.
7. Tripathi, R. P. & Singh, H. P. 1993. Soil Erosion and Conservation. Wiley Eastern.
8. Yellamanda Reddy, T. & Sankara Reddy, G. H. 1992. Principles of Agronomy. Kalyani.

## AGRON 621 RECENT TRENDS IN WEED MANAGEMENT 2 (2+0)

**OBJECTIVE**

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

**COURSE OUTCOME:** Student will have experience on the knowledge of new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

**THEORY**

**UNIT-I:** Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management. Migration, introduction, adaptation of weeds, Invasive weeds-biology and management. Different mechanisms of invasion-present status and factors influencing weed invasion.

**UNIT-II:** Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

**UNIT-III:** Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them. Degradation of herbicides in soil and plants, and factors affecting it. Primary and secondary metabolites, residue management of herbicides, adjuvants.

**UNIT-IV:** Advances in herbicide products and application techniques and methods; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.

**UNIT-V:** Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

**UNIT-VI:** Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelochemical and alleloherbicides, herbicide bioassays. Recent advances in non-chemical weed management including deleterious rhizobacteria, robotics, biodegradable film *etc.*

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**


1. Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. Herbicide Classes in Development: Mode of Action, Targets, Genetic Engineering, Chemistry. Springer, Verlag Berlin, Heidelberg.
2. Chauhan Bhagirath and Mahajan Gulshan. 2014. Recent Advances in Weed Management. Springer, New York, NY (DOI: https://doi.org/10.1007/978-1-4939-1019-9).
3. Das, T. K. 2019. Weed Science: Basics and Applications, Jain Brothers, New Delhi (India)
4. Fennimore, S. A. and Bell, C. 2014. Principles of Weed Control, 4th Ed, California Weed Sci. Soc.
5. Gupta, O. P. 2007. Weed Management: Principles and Practices, 2nd Ed.
6. Gupta, O. P. 2015. Weed Management: Principles and Practices (3rd edition), *Agrobios*
7. Gupta, O. P. 2016. Modern Weed Management (3rd edition), *Agrobios* (India), Jodhpur.
8. Jugulan, Mithila (ed). 2017. Biology, Physiology and Molecular Biology of Weeds. CRC Press.
9. Monaco, T. J., Weller, S. C. and Ashton, F. M. 2002. Weed Science: Principles and Practices. John Wiley and Sons, Inc., New York.
10. Powles, S. B. and Shaner, D. L. 2001. Herbicide Resistance and World Grains, CRC Press.
11. Rao, V. S. 2000. Principals of Weed Science (2nd edition), Oxford and IBH Publishing Co., New Delhi.
12. Saraswat, V. N., Bhan, V. M. and Yaduraju, N. T. 2003. Weed Management, ICAR, New Delhi.
13. Shukla, U. N. 2016. A Practical Manual on Weed Management (Fourth Dean Committee), Department of Agronomy, CoA, Jodhpur (Publication No.: CoA/MND/02/2016)
14. Shukla, U.N. and Mishra, M.L. 2020. A Practical Manual on Weed Management (Fifth Dean Committee), Department of Agronomy, CoA, Jodhpur (Publication No.: CoA/JODH/27/2020)
15. Walia, U. S. 2006. Weed Management, Kalyani Publishers, New Delhi.
16. Zimdahl, R. L. (ed). 2018. Integrated Weed Management for Sustainable Agriculture (1st Edition) Burleigh Dodds Science Publishing Limited, 82 High Street, Sawston, Cambridge, CB22 3HJ , UK (DOI: https://doi.org/10.4324/9781351114417).


| AGRON 622 | INTEGRATED FARMING SYSTEMS AND SUSTAINABLE AGRICULTURE | 2(2+0) |
|---|---|---|

**OBJECTIVE**

To apprise about different enterprises suitable for different agro-climatic conditions for sustainable agriculture.

**COURSE OUTCOME:** Student will have experience on the knowledge of enterprises suitable for different agroclimatic conditions for sustainable agriculture and their proper utilization.

**THEORY**

**UNIT-I:** Integrated Farming systems (IFS): definition, scope and importance; classification of IFS based on enterprises as well as under rainfed/irrigated condition in different land situation. Farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

**UNIT-II:** Concept of sustainability in integrated farming systems; efficient integrated farming systems based on economic viability and natural resources - identification and management.

**UNIT-III:** Production potential of different components of integrated farming systems; interaction and mechanism of different production factors; stability of integrated farming system based on research/long term information in different systems through research; eco-physiological approaches to intercropping. Integration of components and adaptability of different farming system based on land situations and climatic condition of a region; evaluation of IFS.

**UNIT-IV:** Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems. Formation of different integrated farming system models for dryland/irrigated/wetland conditions; evaluation of different integrated farming system models. Recycling of organic waste in farming system.

**UNIT-V:** New concepts and approaches of farming system and organic farming; value addition, waste recycling, quantification and mitigation of greenhouse gases; case studies/success stories of different integrated farming systems. Cropping systems and organic farming; case studies on different farming systems. Possible use of ITK in integrated farming system.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Baishya, A., Borah, M., Das, A. K., Hazarika, J., Gogoi, B. and Borah, A. S. 2017. Waste Recycling through Integrated Farming systems: An Assam Agriculture Experience. Editions Universitaires Europeennes. OmniScriptum GmbH & Co., KG, Bahnhofstrabe 28, 66111 Saarbrucken, Deutschland/Germany.
2. Jayanthi, C. 2006. Integrated Farming Systems-A way to sustainable Agriculture. Tamil Nadu Agricultural University, Coimbatore.
3. Aniket Kalhapure and Madhukar Dhonde. A text book of farming system and sustainable agriculture.
4. Ravisankar, D. and Jayanthi, C. 2015. Farming systems: concepts and approaches. *Agrobios*
5. Balasubramanian, P. and Palaniappan, S.P. 2006. Principles and Practices of Agronomy. *Agrobios* (India).
6. Joshi, M. and Parbhakarasetty, T.K. 2005. Sustainability through Organic Farming. Kalyani Publishers, New Delhi.
7. Lampin, N. 1990. Organic Farming. Farming Press: Ipswich.
8. Palaniappan, S. P. & Anandurai, K. 1999. Organic Farming - Theory and Practice. Scientific Publishers.
9. Panda, S. C. 2004. Cropping systems and farming Systems. *Agrobios* (India).
10. Dhama, A. K. 2014. Organic Farming for Sustainable Agriculture. (2nd Ed.), *Agrobios* (India), Jodhpur.
11. Sharma, A. K. 2013. A Handbook of Organic Farming. *Agrobios* (India), Jodhpur
12. Thapa, U. and Tripathy, P. 2006. Organic Farming in India, Problems and prospects. Agrotech, Publishing Academy, Udaipur.

## AGRON 623 STRESS CROP PRODUCTION 3 (2+1)

**OBJECTIVE**

To study various types of stresses in crop production and strategies to overcome them.

**COURSE OUTCOME:** Student will have experience on the knowledge of various types of stresses in crop production and strategies to overcome these.

**THEORY**

**UNIT-I:** Stress and strain terminology; nature and stress injury and resistance; causes of stress.

**UNIT-II:** Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to mitigate the effect of low temperature stress through soil and crop manipulations.

**UNIT-III:** High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

**UNIT-IV:** Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop manipulations. crop plant adaptation to moisture stress condition

**UNIT-V:** Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.

**UNIT-VI:** Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

**UNIT-VII:** Mechanical impedance in soil and its impact on plant growth; measures to overcome soil mechanical impedance.

**UNIT-VIII:** Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution. Acid stress and Global warming, impact of high wind velocity and relative humidity on crop and their mitigation

**PRACTICAL**

1. Determination of electrical conductivity of plant cell sap;
2. Determination of osmotic potential and tissue water potential;
3. Measurement of transpiration rate;
4. Measurement of stomatal frequency;
5. Measurement of relative water content of leaf;
6. Measurement of electrolytic leakage;
7. Growing of plants in sand culture under salt stress for biochemical and physiological studies;
8. Studies on effect of osmotic and ionic stress on seed germination and seedling growth;
9. Measurement of low temperature injury under field conditions;
10. Studies on plant responses to excess water;
11. Measurement of drought tolerance on the basis of chlorophyll stability index and cell membrane stability;
12. Measurement of proline content in plants during drought.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**


1. Baker, F. W. G.1989. Drought Resistance in Cereals. Oxon, UK.
2. Dwivedi & Dwivedi (2005) Physiology of abiotic stress in plants. *Agrobios*. India
3. Gupta, U. S. (Ed.). 1988. Physiological Aspects of Dryland Farming. Oxford & IBH.
4. Kramer, P. J.1983. Water Relations of Plants. Academic Press.
5. Levitt, J. 1980. Response of Plants to Environmental Stresses. Vols. **I**, **II**. Academic Press.
6. Mavi, H. S.1978. Introduction to Agro-meteorology. Oxford & IBH.
7. Michael, A. M & Ojha, T. P.1981. Principles of Agricultural Engineering. Vol **II**. Jain Bros.
8. Nilsen, E. T & Orcut D.M. 1996. Physiology of Plants under Stress – Abiotic Factors. John Wiley & Sons.
9. Singh, K. 2000. Plant Productivity under Environmental Stress. Agribios.
10. Singh, K. N. & Singh, R. P. 1990. Agronomic Research Towards Sustainable Agriculture. Indian Society of Agronomy, New Delhi.
11. Somani, L. L. & Totawat, K. L. 1992. Management of Salt-affected Soils and Waters. Agrotech Publ.
12. Virmani, S. M, Katyal, J. C, Eswaran, H. & Abrol, I. P.1994. Stressed Ecosystem and Sustainable Agriculture. Oxford & IBH.


## AGRON 624 RECENT TRENDS IN CROP GROWTH AND PRODUCTIVITY 3 (2+1)

**OBJECTIVE:**

To study the physiology of vegetative and reproductive growth in relation to productivity of different crops in various environments.

**COURSE OUTCOME:** Student will have experience on the knowledge of crop growth for agricultural production.

**THEORY**

**UNIT-I:** Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.

**UNIT-II:** Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and Limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

**UNIT-III:** Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; heat unit concept of crop maturity: concept and types of heat units.

**UNIT-IV:** Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, *etc.*; concept and types of growth hormones; their role in field crop production; efficient use of resources.

**UNIT-V:** Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity – partitioning efficiency and harvest index. Crop growth models-empirical models testing and yield prediction.

**PRACTICAL**

1. Field measurement of root-shoot relationship in crops at different growth stages;
2. Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI *etc.*, at different stages of crop growth;
3. Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized;
4. Computation of harvest index of various crops;
5. Assessment of crop yield on the basis of yield attributing characters;
6. Construction of crop growth curves based on growth analysis data;
7. Computation of competition functions, viz. LER, IER aggressivity competition index *etc* in intercropping;
8. Senescence and abscission indices;
9. Analysis of productivity trend in un-irrigated areas;
10. Analysis of productivity trend in irrigated areas.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Chopra, V. L & Paroda, R. S. 1984. Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants. Oxford & IBH.
2. Delvin, R. M. & Vitham, F. H. 1986. Plant Physiology. CBS Publ.
3. Evans, L. T. 1975. Crop Physiology. Cambridge Univ. Press.
4. Evans, L. T. 1996. Crop Evolution, Adaptation and Yield. Cambridge Univ. Press.
5. Gupta, U. S. (Ed.). 1995. Production and Improvement of Crops for Drylands. Oxford & IBH.
6. Gupta, U. S. 1988. Progress in Crop Physiology. Oxford & IBH.
7. Kramer, P. J & Boyer JS. 1995. Water Relations of Plant and Soils. Academic Press.
8. Mukherjee, S. & Ghosh, A. K. 1996. Plant Physiology. Tata McGraw Hill.
9. Narwal, S. S., Politycka, B. & Goswami, C. L. 2007. Plant Physiology Research Methods. Scienti. Pub.
10. Tiaz, L. and Zeiger, E. 2006. Plant Physiology. Sinauer Associates, Inc
11. Hilmann, M. 1990. Synthetic Plant Growth Regulators. *Advance Agronomy*. **43**: 48-105

# COURSE CONTENTS: M.Sc. (Agri.) Organic Farming

**Semester Wise Course Title and Credits: M.Sc. (Agri.) Organic Farming**

| S.No. | Course No. | Credit hour | Course title |
|---|---|---|---|
| **Semester-I** | | | |
| 1. | OF 511* | 2(2+0) | Concepts and principles of organic farming |
| 2. | OF 512* | 4(3+1) | Soil fertility, crop nutrition and nutrients input |
| 3. | OF 513* | 3(2+1) | Organic crop production systems |
| **Semester-II** | | | |
| 4. | OF 521* | 3(2+1) | Organic certification, standards & regulation |
| 5. | OF 522** | 3(2+1) | Plant Health Management |
| 6. | OF 523** | 3(2+1) | Farming systems suitable for organic management |
| 7. | OF 524# | 4(2+2) | Value chain management |
| 8. | OF 525# | 3(2+1) | Research methodology and biostatistics |
| **Semester-III** | | | |
| 9. | OF 531** | 3(2+1) | Organic input management and production technologies |
| 10. | OF 532** | 2(2+0) | Marketing |
| 11. | OF 533# | 2(1+1) | Post harvest handling of organic produce |
| 12. | OF 591 | 1+0 | Master's seminar |
| **Semester-IV** | | | |
| 13. | OF 598 | NC | Comprehensive |
| 14. | OF 599@ | 30 | Master's research/ thesis |

[*Core Courses **Compulsory Courses, #Optional Courses as per Advisory/Departmental Committee, NC-Non-Credit Course, @Credit load of Master's Research (OF-599) shall be depending upon Advisor and starting of research programme of the student in the degree programme].

**Courses requirements: M.Sc. (Agri.) Organic Farming**

| Particulars | M.Sc. (Agri.) Organic Farming |
|---|---|
| Compulsory courses (Core and Major) | OF 511, OF 512, OF 513, OF 521, OF 522, OF 531, OF 532 |
| Optional courses | OF 523, OF 524, OF 525, OF 533 |
| Minor & supporting Courses* | PP 513, PP 514, PP 523, SOIL 513, SOIL 523, PPATH-527, PPATH-535, STAT 512 and STAT 521 |
| Non-Credit compulsory Courses | OF-598, PGS 501, PGS 502, PGS 503, PGS 504 and PGS 505 |
| Seminar | OF 591 |
| Thesis/Research | OF 599 |
| Deficiency courses | As deemed suitable by advisory committee, if any |

***** Suggested by Advisory Committee.

**Semester wise break-up of credit hours M.Sc. (Agri.) Organic Farming**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Non-Credit Compulsory Courses* | Seminar |
|---|---|---|---|---|---|
| **M.Sc. (Agri) Organic Farming** | | | | | |
| I | 3 (9) | 1 (3) | 1 (3) | 3 (3) | - |
| II | 2 (6) | 2 (5) | 1 (3) | 3 (2) | - |
| III | 2 (5) | 2 (3) | - | - | 1 |
| IV | - | - | - | - | - |

***Note:*** No. of credit hours/courses may be increased as per the choice of courses suggested by Advisory Committee of the students.

*PGS Courses (Non-Credit compulsory Courses) shall be compulsory to all students of M.Sc. (Agri.) Organic farming.

**Examination pattern as per BSMA Report:**

| Particulars | Quiz/ Assignment | Mid Term | Final Examination | |
|---|---|---|---|---|
| | | | Theory | Practical |
| Courses with Theory & Practical | 5 | 15 | 50 | 30 |
| Courses with only Theory | 5 | 15 | 80 | - |
| Courses with only Practical | 5 | 15 | - | 80 |

**Pattern of Comprehensive Exam of M.Sc. (Agri.) Organic farming:**

The pattern will be of Written Exam followed by Oral Exam:

**(i) Written Exam:**

M.Sc. (Agri) Organic farming: 2 papers (1 Major + 1 Supporting & Optional subject)

Maximum marks: 100 each

Paper setting: Internal under the Chairmanship of HOD

Evaluation: Internal under the Chairmanship of HOD

Qualifying marks: M.Sc. (Agri) Organic farming: 60% individually.

**(ii) Oral Exam: 100 marks**

M.Sc. (Agri.) Organic farming: After qualifying the Written Exam, the Oral Exam should be conducted by the Students' Advisory Committee in presence of HOD.

Grading of the Comprehensive Exam (M.Sc. & Ph.D.): Satisfactory/ Not Satisfactory.

# COURSE CONTENTS: M.Sc. (Agri.) Organic Farming

## OF 511 CONCEPTS AND PRINCIPLES OF ORGANIC FARMING 2 (2+0)

**OBJECTIVE:** To impart knowledge on the basic concepts of organic farming.

**COURSE OUTCOME:** Student will have basic knowledge on organic farming so as to be an organic trainer, promoter and grower.

**THEORY**

**UNIT–I: Concepts and principles of organic farming** – Basic concepts and definition of organic farming. Characteristics and principles of organic farming. History and evolution of organic farming in the world and India. Scenario of organic farming in India and world, global market of organic products. IFOAM's Guiding principles of organic farming, conversion to organic agriculture, advantages and limitations.

**UNIT–II: Definitions and types of organic farming** - Definitions and types of organic farming such as natural farming, zero chemical natural farming, bio dynamic farming, biological farming, compost farming, Natueco culture, Integrated farming, homa farming, permaculture, green farming etc, traditional farming systems in India and evolving indigenous knowledge systems.

**UNIT–III: Conventional vs Organic farming** - Philosophy of two farming systems, fundamental differences, productivity issues, management protocols, food quality, nutritional differences and impact of conventional practices on soil fertility, natural resources, environment and overall social perception. Myths and realities about organic farming in addressing nutritional security and food safety needs vis-à-vis national food security.

**UNIT-IV: Advocacy, Ethics, health and social issues in organic farmin**g – Advocacy for organic farming with sustainability, resource conservation and food safety issues. Advocacy through overall farm productivity under diversified cropping systems. Spirituality, values and ethics in organic farming. Socio economic importance, issues and its measurements. Need for ethical practices and values across the organic agriculture value chain including trading and reaching to consumers.

**UNIT–V: Organic farming for sustainability, resource conservation, climate change issues and safe and healthy food** – General concerns on sustainability, climate change issues threatening sustainability, potential of organic farming practices in addressing sustainability and climate change. Resource conservation through organic farming, rainwater conservation and preservation of native seeds and germplasm an essential component of organic farming, Consumers concerns on food quality and safety, organic farming for safe and healthy food, ITKs potential and role in sustainability of modern organic farming practices.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion

**SUGGESTED READING:**

1. Bansal, M. 2018. Basics of Organic Farming. Kindle Edition
2. The Complete book of Organic farming and Products of Organic Compost: NPCS Board of Consultants and Engineers. Asia Pacific Business Press Inc.; 2nd Rev. Edition (2021). P-448.
3. Rakshit, A. and Singh, H.B. 2015. ABC of Organic Farming. Jain Brothers, New Delhi
4. Deshpande, W. R. 2009. Basics of Organic Farming. All India Biodynamic and Organic Farming Association, Indore, MP, India P-306.
5. Eyhorn, F., Heeb M. and Weidmann, Gilles IFOAM Training Manual for Organic Agriculture in the Tropics, FiBL and IFOAM.

## OF 512 SOIL FERTILITY, CROP NUTRITION AND NUTRIENTS INPUTS 4 (3+1)

**OBJECTIVE:** To provide knowledge on fertility of soil and different organic inputs used in organic farming.

**COURSE OUTCOME:** Student will have basic knowledge on soil fertility and management in organic farming.

**THEORY**

**UNIT-I**: **Soil – Source of Infinite Life** – Soil as source of life, fundamentals of soil structure and quality, soil fertility, physico-chemical parameters and soil as living entity in organic farming.

**UNIT–II: Soil fertility and productivity** - History of soil fertility and plant nutrition. Factors affecting soil fertility and availability of nutrients; relation between nutrient supply and crop growth; Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

**UNIT–III: Soil fertility evaluation** – Physico-chemical soil testing, biological methods for soil health evaluation, plant and tissue tests; soil quality in relation to sustainable agriculture. Nutrient requirement modeling based on soil health and resources availability.

**UNIT-IV: Soil Conservation and Soil Water Managemen**t – Principles of soil and water conservation, general practices for soil and water conservation, soil carbon build up and biomass recycling.

**UNIT-V: Soil biology and role of microorganisms in soil fertility management** - Soil as a habitat for microorganisms, Soil microorganisms, Soil microbial ecology, Soil microbial biomass, Soil enzymes – origin, activity and importance. Microbial way of agricultural, domestic and industrial wastes management for potential application in organic farming. Microbiology of composting and bio-methanation. Biodegradation of xenobiotics. Bioremediation – principles and application.

**UNIT-VI: Nutrient recycling** – Nitrogen, phosphorus and potash cycles, management for nutrient recycling, methods for recycling and reducing nutrient losses.

**UNIT–VII: Management practices** – Management practices in organic agriculture (mulching, fallowing, intercropping, manuring, crop rotation, agro-forestry, mixed farming);

**UNIT-VIII: Organic fertilizers and composting technology** – Compositing principles and factors affecting composting, dynamics of compositing, methods of composting, different forms of composts with nutrient profiles, Rapid methods of composting, liquid manures, compost enrichment through concentrates, minerals and micronutrients. Field application of composts and their response to crops.

**UNIT-IX: Vermicomposting technology** – Earthworm biology, principles of vermicomposting, methods for vermicompost production, nutrient profiling, field application and its response to crop yields

**UNIT-X: Biofertilizers –** Different types of biofertilizers, their contribution to soil fertility and nutrient pool, factors affecting their application and response of biofertilizers application to crop yields.

**UNIT-XI: Indigenous practices in soil fertility and nutrient management** - Indigenous inputs such as Beejamrit, Jivamrit, Ghanjeevamrit, Panchgavya, on-farm protein hydrolysates, plant extracts and dung-urine slurries, their production methods and effect of their application on soil fertility and crop productivity.

**PRACTICAL**

1. Introduction of analytical instruments and their principles, calibration and applications.
2. Determination of soil pH and electrical conductivity.
3. Determination of soil organic carbon, total and available nitrogen, phosphorus, potassium.
4. Determination of soil calcium, magnesium, sulphur
5. Determination of soil DTPA extractable micronutrients and their interpretations.
6. Biological health assessment through dehydrogenases, soil microbial carbon and $CO_2$ released.
7. Making of composts through aerobic and anaerobic methods
8. Making of vermicomost using earthworms
9. Analysis of manures and composts for major nutrients
10. Microbial profiling of Jivamrit/Panchgavya

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion

**SUGGESTED READING:**

1. Bansal, M. 2018. Basics of Organic Farming. Kindle Edition

2. The Complete book of Organic farming and Products of Organic Compost: NPCS Board of Consultants and Engineers. Asia Pacific Business Press Inc.; 2nd Revised Edition (2021). 448 p.
3. Rakshit, A. and Singh, H.B 2015. ABC of Organic Farming. Jain Brothers, New Delhi
4. Panda, H. (2011). Manufacture of Biofertilizer and Organic Farming. AB Publisher.

## OF 513 ORGANIC CROP PRODUCTION SYSTEMS 3 (2+1)

**OBJECTIVE:** To provide knowledge on organic crop production system.

**COURSE OUTCOME:** Student will have basic knowledge on organic crop production system.

**THEORY**

**UNIT–I: Fundamentals of organic farm management and conversion**– Salient features of organic farm management, strategies for conversion to organic, step-by-step planning, integration of contamination control measures, planning for on-farm input production and supplementary off-farm inputs; planning for rain water harvesting and water conservation approaches including efficient irrigation systems and moisture preservation techniques; visit to organic farms and study on farmer's best practices for conversion.

**UNIT–II: Management of diversity and cropping systems**– Importance of diversity, diversity through plantation of utility trees, nitrogen fixing trees, hedges and crops as intercrops, habitat management for friendly insects, birds; importance of cropping systems management with long term planning, crop rotations, intercropping, multi cropping, relay cropping and multi-storied cropping.

**UNIT–III: Nutrient management**– Components of nutrient management in organic crop production, assessment of crop nutrient requirements, calculation of nutrient credits from on-farm practices and resources such as intercrops, cover crops, biomass mulching, calculating additional input requirements, managing nutrient needs through use of organic manures viz., FYM, compost, vermicompost, oil cakes, *in-situ* and *ex-situ* green manuring, crop residue management, use of restricted organic nutrient sources, liquid organic manures and dung urine slurries, methods of manuring and biomass application, split application of manures, foliar feeding as replacement of top dressing, Indigenous Technical Knowledge (ITKs) and farmers innovations in nutrient management.

**UNIT–IV: Integration of microbial and mineral inputs**– Importance of bio fertilizers, types of biofertilizers, nutrient potential, methods of application, enriching manures/ composts with biofertilizers; identifying the need for use of supplementary mineral sources and their integration in nutrient management package.

**UNIT–V: Weed management**– Prevention of weeds through cropping systems management, crop geometry, stale seedbed technique, summer ploughing, soil solarisation, cover crops, mulching, flooding, biological weed management, selection of suitable physical and mechanical approaches.

**UNIT–VI: Water and irrigation management**– Soil-water relation, theories of water availability, water use efficiency management, methods of irrigation and automation in irrigation systems, irrigation scheduling in different crops.

**UNIT–VII: Modeling of agronomic practices and nutrient management protocols for some important agricultural and horticultural crops**– Identification of compatible associate and intercrops/companion crops, placing trap crops and insectary plants in cropping geometry, making provisions for nutrient credits from biomass mulching, intercrops and green manures, making provisions for nutrient credits from microbial enrichment with microbial/liquid manure inputs, balance nutrient requirement modeling and identification of inputs and planning for quantity and time of application.

**UNIT–VIII: Crop growth and yield analysis**– Crop growth expressions in plants, growth measurements, important growth indices and forms of growth analysis in field crops; factors determining yield; use of growth analysis technique to study variation in yield due to planting season, planting density, fertilizer treatment, other agronomic practices, light, temperature, water, growth substances, varietal differences; crop response curves; dynamics of crop growth and modeling.

**UNIT–IX: Success stories of effective crop management with optimum yields of practicing organic farmers (one in irrigated systems and one in rainfed systems)**– Field visit and documentation of organic farming system with inputs and outputs, identification of practices important for organic systems, nutrient management practices, pest management protocols, yields and economics; Salient features for success and for further replication in crop production modeling.

**PRACTICAL**

1. Visit to organic farms to study general nutrient management practices, documentation of farming system with inputs and outputs.
2. Study of crop growth analysis using crop growth analysis techniques.
3. To study the different tillage methods, rainwater harvesting and water conservation techniques.
4. Production of liquid manures and dung-urine slurries
5. Production of customized composts using FYM/ Compost, mineral nutrients and biofertilizers, assessment of nutrient profiles in enriched composts
6. To study of bio-biofertilizers and their application methods
7. Weed management practices, tools and efficacy of different approaches
8. Indigenous technology knowledge (ITK) for nutrients,
9. To study of irrigation and weed management for organic farming.
10. Modelling of agronomic practices for a given cropping system with use of available resources.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion

**SUGGESTED READING:**


1. Goldammer, T., 2017. Organic Crop Production. Apex Publishers, Virginia.
2. Walia, S. S. 2021. Organic Crop Production. Scientific Publishers (India).
3. Singh, D. P., Prakash, H. G., Swapna, M. and Solomon, S. 2023. Organic Crop Production Management. CRC Press (Taylor & Francis group).
4. Dhama, A. K. 2014. Organic Farming for Sustainable Agriculture. (2nd Ed.), Agrobios (India), Jodhpur.
5. Sharma, A. K. 2013. A Handbook of Organic Farming. Agrobios (India), Jodhpur.
6. Vijayam, G. 2013. Organic Crop Production Technology. CreateSpace Independent Pub.
7. Sharma, V., Sharma, S. K., and Suhail, M. 2018. Organic Farming food production or sustainability. Write & Print Publications, India.
8. Ravisankar, N., Panwar A.S., Prasad, K., Kumar, V. and Bhaskar, S. 2017. Organic Farming Crop Production Guide, Network Project on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh, India.


## OF 521 ORGANIC CERTIFICATION, STANDARDS AND REGULATIONS 3 (2+1)

**OBJECTIVE:** To provide knowledge Organic Certification, Standards and Regulations.

**COURSE OUTCOME:** Student will educating to become a real organic grower.

**THEORY**

**UNIT-I: National and international regulations on quality assurance and certification –** National Programme for Organic Production (NPOP), National Standards for Organic Production (NSOP), USDA NOP Programme and standards, EU Organic standards, Codex Alimentarius, Canada Organic regulation and important differences between NPOP and international standards. FSS Act 2006 for organic food, basic requirements, enforcement, standard operating procedures and verification in value chain.

**UNIT–II: ISO systems for quality assurance (ISO 17065, ISO 17011, ISO 19011 etc) and accreditation processes** – What is ISO, salient features and functions of ISO, ISO systems for auditing, ISO 17065 for auditing and certification agencies, ISO 19011 Inspection protocols, ISO17011 Accreditation requirements, ISO 17025 Accreditation of quality analysis laboratories. Accreditation procedure and policies under NPOP, Essential requirements and competence for making an organic certification body, Conflict of interest management.

**UNIT–III: Types of certification systems (NPOP and PGS), standards and procedures**

**NPOP -** A third party certification systems, Certification bodies operational policies and functions, National standards for crop production, livestock, Aquaculture, Processing and handling and other miscellaneous systems. Tracenet the online data management tool and traceability management

**PGS –** Participatory Guarantee Systems – Evolution of PGS Systems, Guiding principles, PGS Standards, International scenario on PGS development Procedure for organic guarantee under PGS systems, PGS-India programme, operation of PGS-India programme, institutional structure, PGS-India Data management platform, management of traceability.

**UNIT–IV: On-field management of standard compliance and documentation –** Issues for implementation of standards on field such as conversion period, contamination control, fertility management, living condition requirement for livestock, management of integrity in processing and handling, Documentation requirements such as organic system plan, field operation register, input and cultural practices record, processing record, purchase and sales records and product flow in processing.

**UNIT–V: Individual and grower group certification management –** Basic requirements for certification management by (a) Individual producer and (b) Grower/ producer groups. Applicability and types of systems covered.

**UNIT–VI:** Inspection (under NPOP) and peer review (under PGS) systems – Fundamental principles of inspection, Development of inspection formats, checklists and inspection parameters, general policy frame work

**NPOP–**Third party inspection procedure, risk assessment, documentation and record keeping review, physical verification of facilities, fields and stables, production facilities, estimated yield/production assessment, tracking the product flow throughout the process, chain of custody. Review of inspection forms and checklists and certification decisions.

**PGS-India–**Peer review principles, making of peer review committees and peer review checklists, analysis of peer review checklists and certification decisions. Submission of summary sheets to regional councils and assessment and endorsement of certification decisions.

**UNIT-VII: Certification of crop, livestock, aquaculture and other systems –** Standards, their implementation in production systems, measures for contamination control, integrity management, sanitation and hygiene, input evaluation procedures, development of process tracking checklists.

**UNIT–VIII: Certification of processing, handling, trading and management of traceability** - Standards, their implementation in production/ processing and handling systems, measures for contamination control, integrity management, sanitation and hygiene, packaging and labelling, development of process tracking checklists

**UNIT–IX: Internal control system management in large farmer groups under NPOP** – Large farmer groups, essential requirements, internal control systems, development of ICS operating manual, management of ICS, internal inspections, risk assessment, assessment of internal inspections and certification decisions, additional documentation for groups, produce/ output management and sale record management

**UNIT-X: PGS Group development and PGS certification managemen**t – Essential requirements for local groups, development of local group operating manuals, requirements of group meetings and trainings, decision making by farmers, operational policies for Regional Councils, developing operating manual for councils, assessment of summary sheets and decisions of local groups, procedure for decision endorsement and certification granting

**PRACICAL**

1. Documentation of certification procedures, acquaintance with record keeping, handling, labelling and preparation of farmers IDs for developing ICS.
2. Visit to certification bodies, certified farms, certified processing and handling operations
3. Development of organic system plan for specific production system
4. Development of inspection format and checklists for specific production system
5. Development of operating procedures on specific aspects
6. Risk assessment on organic farms and possible mitigating measures
7. Running of audit trails in certified operations

8. Mock inspections of different production systems
9. Exercise on inspection report/ peer evaluation checklist review and certification decision
10. Exercise on methods of yield assessment

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion

**SUGGESTED READING:**


1. Bansal, M. 2018. Basics of Organic Farming. Kindle Edition.
2. Rakshit, A. and Singh, H.B 2015. ABC of Organic Farming. Jain Brothers, New Delhi.
3. Reddy, S. R. 2017. Principles of Organic Farming. Kalyani Publisher, New Delhi.
4. Gupta, S. and Pathak, S. 2021. Organic Farming. Kalyani Publisher, New Delhi.
5. Walia, S. S. 2021. Organic Crop Production. Scientific publishers, New Delhi.
6. Walia, S. S. and Nanwal, R. K. 2022. Principles of Organic Farming. New India Publishing Agency.
7. Maliwal, P.L. 2021. Principles of Organic Farming: Scientific publishers.


## OF 522 PLANT HEALTH MANAGEMENT 3 (2+1)

**OBJECTIVE:** To provide knowledge on plant health management for optimization of crop yield due to organic farming.

**COURSE OUTCOME:** Student know, how the plant health will be taken care of for optimization of higher crop yield due to organic farming.

**THEORY**

**UNIT–I: Classification of pest organisms** – Classification of pests viz. weeds, bacteria, nematodes, fungi, insects, viruses, vertebrates, etc, identification of pests and beneficial organisms.

**UNIT-II: General principles of plant health management in organic farming** - Principles of pest management in organic crop production; Pest survey and surveillance, estimation of pest population and their damage; concept of injury level's, principles of Agro Eco-System Analysis (AESA) based pest management, estimation of Pest : Defender (P:D) ratio, understanding AESA methodology.

**UNIT-III: Biology of pests and population dynamics** – Incidence and population dynamics in relation to environment, distribution, identification; Life cycle of key pests of cereals, pulses, vegetables, stored grains, fruit crops and protected cultivation.

**UNIT-IV: Ecological strategies for pest management** - proper field sanitation, appropriate fertilization, necessary pruning, use of resistant varieties, seed treatment, sowing time, crop rotation, avoidance of endemic sites, plant quarantine regulation and legal strategies, use of insectary plants, trap crops and planning for diversity plant integration as border crops, hedge rows, intercrops etc.

**UNIT–V: Cultural and physical control strategies** – Importance and use of traps, sticky traps, light traps, pheromone traps, pan traps etc and soil sterilization, solarization, hot and cold treatments etc.

**UNIT–VI: Biological control** – Role of biological control in the insect pests and nematodes, Conservation of natural enemies, classical biological control systems, important beneficial insects and their integration in different cropping systems.

**UNIT–VII: Biopesticides** – Classification of biopesticides with their mode of action, production, methods of application and impact assessment on crops and pest load.

**UNIT–VIII: Botanical pest management** – Using different plants for management of different pests, methods for using such plants and active ingredient extraction methodologies, formulation of usable solutions and methodologies for application. Integrated strategies, development of crop specific integrated management modules, importance and need for chemical alternatives permitted in organic farming, methods for use and application.

**UNIT–IX: Indigenous practices and their importance in plant protection** – Indigenous practices of avoiding pests, managing pests, important plants being used since ages and innovative botanical and fermentation inputs developed by farmers for pest management.

**UNIT–X: Pest control of produce in storage** – Physical, mechanical and biological approaches, modified environment, management of hygiene and phyto-sanitary approaches, use of organically acceptable fumigants such as carbon dioxide and nitrogen.

**PRACTICAL**

1. Collection and Identification of major/key pests and plant diseases,
2. Estimation of pest population, nature of damage, assessment of crop losses,
3. Calculations based on ETL and EIL concept
4. Familiarization with important crop pests & diseases and their biological control agents,
5. Demonstration/familiarization with various tools of insect-pest & disease management,
6. Mass production technologies of important biopesticides
7. Preparation of organic/natural formulations for insect-pest & disease management,
8. Evaluation of organic formulations for determining their pesticidal properties and field efficacy.
9. Preparation and validation of traditional formulations.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion

**SUGGESTED READING:**

1. Mukherjee, A., Dutta, S., Goyal, T M., Kapoor, A. and Mendiralta, D. 2017. Organic farming in India: Status, issues and way forward. Academic Foundation
2. Dhaliwal, G. S. and Koul, O. 2007. Biopesticides and pest management (Conventional and Biotechnological approaches). Kalyani Publishers, New Delhi
3. Dhaliwal, G. S. and Arora, R. 2006. Integrated pest management (Concept and approaches). Kalyani Publishers, New Delhi
4. Integrated pest management package for agricultural crops published by NRC-IPM, New Delhi and Sometimes DPPQS & NIPHM.
5. Metcalf, R. L. and Luckmann, W. H. 1982. Introduction of Insect Pest Management. A Wiley – Interscience Publication, 561 p.
6. Bansal, M. 2018. Basics of Organic Farming. Kindle Edition
7. The Complete book of Organic farming and products of organic compost: NPCS Board of consultants and Engineers. Asia pacific business press Inc.; 2nd Revised Edition 2021. .
8. Rakshit, A. and Singh, H.B 2015. ABC of Organic Farming. Jain Brothers, New Delhi
9. Reddy, S. R. 2017. Principles of Organic Farming. Kalyani Publisher, New Delhi.

## OF 523 FARMING SYSTEMS SUITABLE FOR ORGANIC MANAGEMENT 3(2+1)

**OBJECTIVE:** To familiar with most appropriate farming systems under organic management.

**COURSE OUTCOME:** Student will know leadership development for an organic entrepreneur.

**THEORY**

**UNIT–I: Introduction**: Farming systems: Definition, importance and scope, Classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply and enterprises, Concept of sustainability in farming systems,

**UNIT–II: Agro-ecology:** Concepts and practices of agro-ecology, Design of sustainable agro-ecosystems, Ecological processes to optimize agro-ecosystems, Sustainable Agriculture: Basic, definitions and concepts, Alternative sustainable farming systems, Low external input sustainable agriculture (LEISA).

**UNIT–III: Enterprises selection and Integration:** Natural Farming, Integrated Farming Systems, Pre-dominant farming systems in various regions, Eco-physiological approaches, component selection and integration, Complementary and competitive interaction, Primary, secondary, complimentary and supplementary enterprises for organic farming, Livestock based farming systems, vertical farming, Principles and Practices of organic livestock production, Principles of organic aquaculture, Organic fruit and vegetable production practices, Models of integrated farming systems for irrigated, rainfed and dryland ecosystems.

**UNIT-IV: Modelling in farming systems**: Simulation models for intercropping, farming system design using farm design for various resource conditions, Linear programming, Multi-objective criteria decision making, Fuzzy logic analysis, Artificial Neural Network (ANN) based modelling, DSSAT, Infocrop, Cropsyst, Livesim.

**UNIT–V: Integrated Organic Farming Systems:** Concepts, Principles, Strategies, Diversity plantations, crop rotations, soil fertility management, Selection of seeds, varieties and planting material, nutrient management, weed and pest management, integration of livestock, breeds and allied activities, In-situ recycling of Organic wastes, Products and processes of composting, Component optimization, Market input chain, family employment generation, case studies, Supplementary, complimentary and substitution effects under dry-land, irrigated, wetland and hill-zone eco systems.

**UNIT–VI: Soil-crop-livestock-human chain:** Bio-nutrition concepts, design farming systems for nutrition, Household level production of food, feed, fodder, compost, fuel and fibre from farming systems.

**UNIT–VII: Secondary Agriculture:** Product diversification, Process diversification, Processing of marketable surplus produces, packaging, branding and marketing.

**UNIT-VIII: Contract Farming:** Farming system based cluster formation, production, processing and marketing, legal aspects of contract farming.

**UNIT-IX: Specialized farming systems:** Protected cultivation, high value crops based systems, aqua-based farming systems, Region specific integrated farming systems, medicinal herb based systems.

**UNIT–X:—Farming System diversification:**—Existing scenario of farming systems, Crop diversification: needs, approaches and its method for calculation.

**UNIT–XI: Four P Model of organic farming system:** 4P (Planning, Production, Processing and Promotion) model of organic farming systems.

**UNIT–XII: Ecological Engineering:** Principles and Practices, Ecological engineering approach of soil fertility and pest management, examples of ecological engineering in traditional farming systems, case studies.

**PRACTICAL**

1. Agro-ecosystem analysis: Field study of farming systems in the context of production flows, energy flows using quantitative tools
2. Pest dynamics using quantitative tools
3. Farming System typology analysis and clustering of group of farmers
4. Synthesis of organic farming system model for a given region using primary and secondary data
5. Estimation of ecological, economic, social and sustainable livelihood indicators for a given farming system
6. Design of alternative farming systems using Farm Design and other available modelling tools
7. Experiential learning on different enterprises
8. Documentation of farming system case studies
9. Study of sustainable value and sustainable yield index for various farming systems.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion

**SUGGESTED READING**


1. Bansal, M. 2018. Basics of Organic Farming. Kindle Edition
2. The Complete book of Organic farming and products of organic compost: NPCS Board of consultants and Engineers. Asia pacific business press Inc.; 2nd Revised Edition 2021. 448 p.
3. Rakshit, A. and Singh, H.B 2015. ABC of Organic Farming. Pub. by Jain Brothers, New Delhi
4. W. R. Deshpande 2009. Basics of Organic Farming:, All India Biodynamic and Organic Farming Association, Indore, MP, India P-306.
5. Eyhorn, F., Heeb M. and Weidmann, Gilles IFOAM Training Manual for Organic Agriculture in the Tropics, FiBL and IFOAM.

**OF 524 VALUE CHAIN MANAGEMENT 4(2+2)**

**OBJECTIVE:** To provide knowledge on value chain for optimization of crop yield due to organic farming.

**COURSE OUTCOME:** Student will able to know the high value in organic products.

**THEORY**

**UNIT–I: Introduction –** What is value chain? Defining value chain and its finance (Internal value chain finance, External value chain finance, Interest around value chain finance in agriculture, interest in value chain finance in agriculture); Overview of value chain managementand value chain optimisation

**UNIT–II: Understanding agricultural value chain finance –** Context, the concept of agricultural value chain finance, Agricultural value chain finance as an approach, Enabling environment (standards and certification, regulation and enforcement, macro-economic and social context), and Value chains and diversified livelihoods.

**UNIT-III: Value chain business models -** Producer-driven value chain models, Buyer-driven value chain models, Facilitated value chain models, and Integrated value chain models. Case Study 1. On commercial village approach.

**UNIT–IV: Agricultural value chain finance instruments** - Product overview, Product financing (trader credit, input supplier credit, marketing company credit, lead firm financing), Receivables financing (Trade receivables finance, factoring and forfeiting), Physical asset collateralization (warehouse receipts, repurchase agreements, financial lease), Risk mitigation products (crop/weather insurance, forward contracting, futures), Financial enhancements (securitization, loan guarantees, joint ventures). Case Study 2. Producer-driven financing of farm inputs: informal inventory credit; Case Study 3. Integrated financial instruments and value chain services

**UNIT–V: Innovations-** Value chain innovations, Financial innovations, Technological innovations (management systems, networks and exchanges, mobile phones and mobile banking), Infrastructural innovations, Policy and public sector innovations. Case Study 4. Technological innovations; Case Study 5. Avenues for sustainable agricultural development.

**UNIT–VI: Leadership Approaches for Successful Food Value Chain**s – Values-Based Leadership, Values-Based Leadership in Practice, Leadership in succession.

**UNIT–VII: Organic food value chain management.**

**PRACTICAL**

1. Collection, aggregation and value addition
2. Maintain quality and integrity of the product - practices and procedures, monitoring practices and procedures followed, record keeping systems, management practices and separation measures, handling and processing of organic products
3. Pest control - Treatments with pest regulating agents – permitted [physical barriers, sound, ultra-sound, light and UV-light, traps (incl. pheromone traps and static bait traps), temperature control, controlled atmosphere and diatomaceous earth] and prohibited
4. Ingredients - approved and prohibited ingredients (microorganisms, minerals, gases)
5. Processing methods - permitted and prohibited mechanical, physical and biological
6. Packaging - permissible biodegradable, recyclable, reusable systems and eco-friendly packaging
7. Labeling- labeling requirements for agricultural commodities and processed food
8. Storage and Transport - permitted conditions of storage to maintain product integrity
9. Food additives including carriers for use in production of processed organic food
10. Processing aids and other products for use for processing of ingredients of agricultural origin from organic production flavouring agents, Preparations of Micro-organisms, Ingredients
11. Approved products for packaging of organic food stuffs incl. Permissible packaging material for aquaculture

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion.

**SUGGESTED READING**

1. Handfield, R. and Nichols, E. 1998. Introduction to supply chain management. Pearson.
2. Christopher, M. 2004. Logistics and supply chain management: creating, value adding networks. Financial times.
3. Singh, K. A. 2021. Hand Book on Supply Chain Management. Kindle Edition
4. Wisner, J. D., Keah-choon Tan and Leong, G. 2018 (5th edition). Principles of supply chain management South-Western College Publishing.
5. Raphael Kaplinsky and Mike Morris. 2002. A Handbook for Value Chain Research.
6. Purushothaman, S. 2022. Logistics and supply chain management. Sultan Chand and Sons.
7. Subbulakshmi, G. and Udipi, S. A. 2008. Food Processing and Preservation. New Age International Pvt. Ltd.
8. Rao Eram S. 2013. Principles of Food Science A Practical Manual (Pb). Daya Publishing House.
9. Souza, D. and Pradhan. 2010. Handbook of Food Processing, Packaging and Labeling. SBS Publishers and Distributors Pvt. Ltd.
10. Pomeranz, Y. and Meloan, C. E. 2004 (3rd Ed.). Food Analysis Theory and Practice. Springer
11. National Programme for Organic Production- A Training Manual, APEDA, New Delhi Inner (apeda.gov.in).


## OF 531 ORGANIC INPUT MANAGEMENT AND PRODUCTION TECHNOLOGIES 3 (2+1)

**OBJECTIVE:** To provide knowledge on various organic inputs, their production technologies, quality control and commercialization aspects.

**COURSE OUTCOME:** Student will have basic knowledge on marketing to get higher prices in organic produces.

**THEORY**

**UNIT–I: Introduction**

Need for on-farm and off-farm (external) organic inputs, types of organic inputs allowed under organic farming, regulatory scenarios and standards. Status of organic and biological input industry in the country.

**UNIT–II: On-farm inputs for soil fertility and nutrient management**

Types of on-farm inputs for soil fertility and nutrient management, their need assessment under specific cropping systems vis-à-vis soil test reports, methodologies for recycling of on-farm biomass and crop residue, innovative traditional inputs such as *jivamrit, beejamrit, panchgavya* etc. their microbial profiling and nutrient mobilization potential and standardized production methods, Oil cakes and their applications.

**UNIT–III: On-farm inputs, plant health management and pest control**

Types of plant protection inputs and intervention approaches, use of biological and ecological approaches, preventive practices, Types of plants used in plant protection and their biological characterization for pest control, basic methodologies for active ingredient extraction and on-farm formulations.

**UNIT–IV: Composts and their value added products**

Types and methods of composting, their characteristics, nutrient potential, factors controlling the process of composting, value added composts, quality control parameters, commercial production methodologies for city waste compost, Phosphate Rich Organic manure (PROM), phospho-compost, bio-organic manure, waste decomposer, technologies for product formulations such as enrichment and granulations etc.

**UNIT-V: Biofertilizers**

Types of biofertilizers, standards for commercial products, testing methodologies, characterization and efficiency parameters, management of microorganisms in laboratory, biofertilizer production methodologies such as mother culture development, mass production through fermentation and fermentation parameters, mass scale culture techniques, product formulations, carrier-based inoculants, liquid inoculants and lyophilized inoculants.

**UNIT–VI: Microbial Biopesticides**

Biopesticides, importance of biopesticides, Types of biopesticides, Mechanisms of action of biopesticides, Registration guidelines for biopesticides, standards for commercial products, testing methodologies, characterization and efficiency parameters, preparation and maintenance of pure cultures of microorganisms in the laboratory, production methodologies such as mother culture development, mass production through fermentation and fermentation parameters, mass scale culture/mass production techniques, product formulations, carrier-based inoculants, liquid inoculants and lyophilized inoculants. Types of polyhedrosis and granulosis viruses and their production methodologies

**UNIT–VII: Mass rearing of beneficial insects**

Introduction to beneficial insects such as predators and parasites, classification and identification, mass rearing technologies including rearing of host insects, and their release in the field

**UNIT–VIII: Botanical pesticides and other non-chemical pest protectants**

Type of non-chemical plant protection options, importance of soft soaps and oils, important plants having pesticidal properties, plant parts having pesticidal active ingredient and their extraction methodologies, product formulation and stabilization for increased shelf life, field assessment of efficacy. Regulatory scenario and quality parameters.

**PRACTICAL**

1. Getting familiarized with on-farm soil fertility management inputs (such as *beejamrit, jivamrit, panchgavya* etc), ingredients needed and production methodology. Preparation and quality assessment
2. Application of such inputs in small plots on selected crops and observation on growth
3. Production of different composts including vermicompost
4. Quality analysis of composts for nutrients and heavy metals
5. Biofertilizer organisms, their laboratory characterization, sub-culturing and mother culture development
6. Fermentation technology demonstration, production of bacterial broth in pilot scale fermenters
7. Biofertilizer product formulations and quality analysis methods
8. Study biopesticide organisms, laboratory culturing, mass cultivation using solid state fermentation, liquid fermentation and spore harvesting methods and product formulations
9. Visit to beneficial insect rearing laboratory and handling of insects including demonstration on tricho-cards production
10. Extraction of neem seed kernel extracts and neem oil. Production of botanical extracts and product formulation using emulsifiers
11. Study effect of various botanical extracts on insect pests
12. Exposure visit related to organic input production unit and farm

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion. Practical in the laboratory, visit to production sites and demonstration of production protocols through industry visits, practical on analysis protocols

**SUGGESTED READING**


1. The Complete Technology Book on Vermiculture and Vermicompost, NPCS Board of consultants and Engineers, Asia Pacific Business Press
2. ESF and Seecon 2006. Training material on Composting and Vermicomposting, Ecosan Services Foundation (ESF) and Seecon
3. Hannabasava, A. C. and Lakshman, H.C. 2014. Biofertilizers and Biopesticides. Pointer Publishers.
4. Deshmukh, A. M., Khobrgade, R. M. and Dixit, P. P. 2007. Handbook of Biofertilizers and Biopesticides. ABD Publishers.
5. Juan A. Morales-Ramos, M. Guadalupe Rojas and David I. Shapiro-Ilan. 2013. Mass Production of Beneficial Organisms, Academic Press.
6. Meena, V.K., Meena, S.K., Rakshit, A. Stanley, J. and Rao, S. 2021. Advances in Organic Farming: Agronomic soil management practices. Elsevier.
7. Maliwal, P.L. 2021. Principles of Organic Farming: Scientific publishers

8. Singh, A.K. 2009. Production Technology on Bio Organic farm inputs. International Book Distributing Co. Lucknow, U.P.
9. Sharma, A. K. 2002. A handbook of Organic Farming by, Agrobios (India), Jodhpur.
10. Comprehensive Training manual on Organic Farming by National Centre for Organic & Natural Farming (NCONF), Ghaziabad.

| OF 532 | MARKETING | 2 (2+0) |
|---|---|---|

**OBJECTIVE:** To provide knowledge on marketing of organic produce for economic profit of the grower.

**COURSE OUTCOME:** Student will have basic knowledge on marketing to get higher prices in organic produces.

**THEORY**

**UNIT–I: What is marketing and marketing functions–**Facets of marketing, Facilitating functions of a market, Evolution of marketing: From transaction- based to relationship marketing- Marketing research and Decision support systems .Market Segmentation, Targeting and Positioning What's special about agricultural markets? Pricing policy and Role of prices.

**UNIT–II: Basics of Supply and Demand** – Demand, Aggregate demand, Supply and Aggregate supply

**UNIT-III**: **Food Marketing Channel–** Understanding the food marketing channel, Scenario Analysis.

**UNIT–IV: Market intelligence–** Market research, Production cost assessment, Projecting Revenues, Accounting, Market Selection

**UNIT–V:** Organic production and domestic market size, Institutional context and regulations (such as NPOP, NSOP, APGMC Act, PGS, FSSAI, Jaivik Bharat).

**UNIT–VI: Organic Food Distribution System**- Domestic market structures, and classification framework, urban organic retail models, Organic specialty stores, markets and health food stores. Direct marketing and Community Supported Agriculture.

**UNIT–VII: Market potential for organic foods-** Consumer preferences and perceptions (organic sensitivity, building awareness on organic foods and consumer needs, shopping Behavior, factors influencing purchases of new foods), general trade and organized retail,

**UNIT–VIII: e-Marketing and e-consumer perceptions and Behavior–** Why organic food, source and perception of organic foods, uses of organic food, resistance to use organic products, source of awareness, organic food-is it a fad?, On-line retail and home delivery services, role of advertising and choice of media, understanding the role of quality in marketing, perception of health benefits and assurance/certification. Marketing institutions

**UNIT–IX:** Accessibility of organic foods, premiums and willingness to pay premiums, role of retailer.

**UNIT–X**: Efficient supply chains and retail channels, sustainability of supply chain.

**UNIT–XI: Consumer purchase behavior and habits–** Shopping Behavior, role of influencer in decision making, concern over adulteration, chemicals, loss of nutrients and vitamins during processing and manufacturing and its impact on marketing and sale

**UNIT-XII**: **Challenges and success stories** – Success stories in organic marketing, organizational models, their advantages, challenges, limitations and legal context.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion

**SUGGESTED READING**

1. Acharya, S.S. and Agarwal, N.L. 2020. Agricultural Marketing in India. CBS publishers and distributors Pvt Ltd.
2. Acharya, S.S. 1988. Agriculture Production Marketing and price policy. Mittal Publications, New Delhi.
3. Bhattacharya, S. 2011. Marketing management. National Publishing House, Jaipur

4. Brunk, M.E. and Darrah, L.B. 1955. Marketing of Agriculture products. The Ronald Prewss Company, New York.
5. Gupta, A.P. 1975. Markting of Agriculture Produce in India. Vora and Company publishers Pvt. Ltd. Mumbai.

## OF 533 POST HARVEST-HANDLING OF ORGANIC PRODUCE 2 (1+1)

**OBJECTIVE:** To provide knowledge on post-harvest handling of organic produce for optimization of crop yield due to organic farming.

**COURSE OUTCOME:** Student know plant health will be taken care of for optimization of higher crop yield due to organic farming.

**THEORY**

**UNIT-I: Pre/Postharvest Factors for Post-harvest Losses of Organic Produce** - Pre and post-harvest factors responsible for causing organic produce losses. Principles and practices responsible for losses of organic agricultural produce. Qualitative, quantitative, nutritional and socioeconomic losses. Loss assessment and estimation techniques and their limitations and methods for reducing post-harvest losses.

**UNIT-II: Introduction to Value Chain and Handling of Fresh Organic Products for Processing-** Management of hygiene and phyto-sanitary measures, measures to reduce field heat, precooling methods, cleaning and washing, control of enzymatic and non-enzymatic changes, transportation, sorting, grading, peeling, sampling and size reduction, packaging, labelling; handling methods for fresh fruits, vegetables and flowers.

**UNIT-III: Organic Food Processing and Preservation**-Fundamental principles for food processing in organic farming, acceptable processing techniques, use of preservatives, processing aids, flavouring agents and nutrient supplement in organic food and feed processing, novel thermal and non-thermal processing methods.

**UNIT–IV: Food Standards and Residue Analysis/Toxicology -** Fundamental principles of food standards, HACCP system, US and European Export/Import standards for different crops, MRLs, sources of contamination, assessment and management of residues and toxins in food, critical control points, heavy metals and pesticide residue analysis, analytical methods and tools. Interpretation of residue analysis reports, analysis protocols and GMO report analysis.

**UNIT–V: Principles of Packaging**- Characteristics of packaging materials for organic food, packaging requirements for fresh and processed organic food for local and international markets, labelling requirements for fresh and processed organic food for local and international markets, labelling requirements and management integrity, emerging packaging technologies.

**PRACTICALS**

1. Study of maturity indices for harvest of organic fruits, vegetables, spices and plantation crops.
2. Determination of physiological loss in weight and respiration rate in fruits and vegetables.
3. Determination of chemical constituents like sugar, starch, pigments, vitamin C, carotenes, acidity during maturation and ripening in fruits/vegetables.
4. Protective skin coating with organic wax emulsion to extend the shelf life of fruits and vegetables.
5. Study of effect of precooling on shelf-life and quality of fresh fruits, vegetables and flowers.
6. Study of packages-bulk and consumer packs for different fruits, vegetables, flowers and spices.
7. Study of construction and working of zero energy cool chamber. Study of storage behaviour of different fruits and vegetables in zero energy cool chamber.
8. Preparation and preservation of fruit-based beverages and blended products from fruits and vegetables.
9. HACCP analysis, residue analysis in organic products. Visit to packaging centres, local markets, cooperative organisations, super markets dealing with marketing of organic perishables.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, assignment and class discussion

**SUGGESTED READING**


1. Bansal, M. 2018. Basics of Organic Farming. Kindle Edition
2. The Complete book of Organic farming and products of organic compost: NPCS Board of consultants and Engineers. Asia pacific business press Inc.; 2nd Revised Edition (2021). 448 p.
3. Rakshit, A. and Singh, H.B (2015). ABC of Organic Farming. Published by Jain Brothers, New Delhi
4. W. R. Deshpande (2009). Basics of Organic Farming:, All India Biodynamic and Organic Farming Association, Indore, MP, India P-306.
5. Eyhorn, F., Heeb M. and Weidmann, Gilles IFOAM Training Manual for Organic Agriculture in the Tropics, FiBL and IFOAM.

# DEPARTMENT OF GENETICS AND PLANT BREEDING
# AGRICULTURE UNIVERSITY, JODHPUR

**Semester Wise Course Title and Credits: M.Sc. (Agri.) Genetics and Plant Breeding**

| S.No. | Course No. | Title | Credit hours |
|---|---|---|---|
| **Semester-I** | | | |
| 1. | GPB 511* | Principles of Genetics | 3 (2+1) |
| 2. | GPB 512* | Principles of Plant Breeding | 3 (2+1) |
| 3. | GPB 513* | Fundamentals of Quantitative Genetics | 3 (2+1) |
| **Semester-II** | | | |
| 4. | GPB 521** | Principles of Cytogenetics | 3 (2+1) |
| 5. | GPB 522# | Breeding for Quality and Special Traits | 3 (2+1) |
| 6. | GPB 523# | Mutagenesis and Mutation Breeding | 3 (2+1) |
| 7. | GPB 524# | Crop Breeding-II (*Rabi* Crops) | 3 (2+1) |
| 8. | GPB 525# | Breeding for Vegetable Crops | 3 (2+1) |
| 9. | GPB 526# | Breeding for Fruit Crops | 3 (2+1) |
| 10. | GPB 527# | Breeding for Ornamental Crops | 3 (2+1) |
| 11. | GPB 528# | Breeding for Stress Resistance and Climate Change | 3 (2+1) |
| **Semester-III** | | | |
| 12. | GPB 531** | Molecular Breeding and Bioinformatics | 3 (2+1) |
| 13. | GPB 532# | Hybrid Breeding | 3 (2+1) |
| 14. | GPB 533# | Crop Breeding-I (*Kharif* Crops) | 3 (2+1) |
| 15. | GPB 534# | Varietal Development and Maintenance Breeding | 2 (1+1) |
| 16. | GPB 535# | Seed Production and Certification | 2 (1+1) |
| 17. | GPB 536# | Germplasm Characterization and Evaluation | 2 (1+1) |
| 18. | GPB 537# | Genetic enhancement for PGR Utilization | 2 (1+1) |
| 19. | GPB 591** | Master's Seminar | 01 |
| **Semester-IV** | | | |
| 20. | GPB 598** | Comprehensive | Non-Credit |
| 21. | GPB 599** | Thesis/Research | 30 |

* Core Courses (External Examination), ** Compulsory Courses (As per PG/ Ph.D. Guidelines).
\# Optional Course.

**Courses Requirement for M.Sc. (Agri.) Genetics and Plant Breeding**

| | |
|---|---|
| Core courses | GPB 511, GPB 512, GPB 513 |
| Compulsory courses | GPB 521, GPB 531 |
| Optional courses* | GPB 522, GPB 523, GPB 524, GPB 525, GPB 526, GPB 527, GPB 528, GPB 532, GPB 533, GPB 534, GPB 535, GPB 536, GPB 537 |
| Minor & supporting Courses* | STAT 512, STAT 513, STAT 521, STAT 523, MBB 511, MBB 521, MBB 522, PP 513, PP 514, PP 523, PP 533, PP 535, ENTO 523, ENTO 525, ENTO 532, PPATH 522, PPATH 533, PPATH 536 |
| Non-credit compulsory Courses | GPB 598<br>PGS 501, PGS 502, PGS 503, PGS 504 and PGS 505 |
| Seminar | GPB 591 |
| Thesis/Research | GPB 599 |
| Deficiency courses | Nil or as deemed suitable by Advisory Committee |

* Course as suggested by Departmental/ Advisory committee meeting or BOS.

**Semester wise breakup**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Common compulsory Course (Credit) | Seminar |
|---|---|---|---|---|---|
| I | 3 (9) | 1 (3) | 1 (3) | 3 (3) | - |
| II | 2 (6) | 1 (3) | 1 (3) | 2 (2) | - |
| III | 2 (5) | 1 (3/2) | - | - | 1 |
| IV | - | - | - | - | - |

**Semester Wise Course Title and Credits: Ph.D. Genetics and Plant Breeding**

| S.No. | Course No. | Course Title | Credit hour |
|---|---|---|---|
| | | **Semester-I** | |
| 1. | GPB 611* | Advances in Plant Breeding Systems | 3(3+0) |
| 2. | GPB 612* | Genomics in Plant Breeding | 3(3+0) |
| 3. | GPB 691** | Doctoral Seminar I | 01 |
| | | **Semester-II** | |
| 4. | GPB 621** | Advances in Biometrical Genetics | 3(2+1) |
| 5. | GPB 622** | IPR and Regulatory Mechanism (e-course) | 1(1+0) |
| 6. | GPB 623# | Breeding Designer Crops | 2(1+1) |
| 7. | GPB 624# | Molecular Cytogenetics for Crop Improvement | 2(2+0) |
| 8. | GPB 625# | Crop Evolution | 3(3+0) |
| 9. | GPB 626# | Plant Genetics Resources, Conservation and Utilization | 2(2+0) |
| 10. | GPB 627# | Population Genetics | 2(2+0) |
| 11. | GPB 692** | Doctoral Seminar II | 01 |
| | | **Semester-III to VI** | |
| 12. | GPB 698** | Preliminary Exam | Non-Credit |
| 13. | GPB 699** | Thesis/Research | 75 |

* Core Courses (External Examination), ** Compulsory Courses (As per PG/ Ph.D. Guidelines)

**Courses Requirement for Ph.D. Genetics and Plant Breeding**

| | |
|---|---|
| Compulsory courses | GPB 611, GPB 621, |
| Optional courses# | GPB 612, GPB 622, GPB 623, GPB 624, GPB 625, GPB 626, GPB 627 |
| Minor & supporting Courses* | STAT 512, STAT 513, STAT 521, STAT 523, MBB 511, MBB 521, MBB 522, PP 513, PP 523, PP 533, PP 535, ENTO 523, ENTO 525, ENTO 532<br>PPATH 522, PPATH 533, PPATH 536 |
| Non-credit compulsory Courses | GPB 698<br>PGS courses** |
| Seminar | GPB 691, GPB 692 |
| Thesis/Research | GPB 699 |
| Deficiency courses | Nil or as deemed suitable by advisory committee |

* Courses as suggested by Departmental/ Advisory committee meeting or BOS. ** Courses, if not studied during Master's Degree Programme, # Optional Course

**Semester wise Breakup**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Common compulsory Course (Credit)* | Seminar |
|---|---|---|---|---|---|
| I | 2 (6) | 1 (3) | 1 (3) | 3 (3) | 1 |
| II | 3 (6) | 1 (3) | 1 (3) | 2 (2) | 1 |

*If not studied during Masters

**Examination Pattern: M.Sc. (Agri.) Genetics and Plant Breeding and Ph.D. Genetics and Plant Breeding**

| Particulars | Quiz/ Assignment | Mid Term | Final Examination | |
|---|---|---|---|---|
| | | | Theory | Practical |
| Courses Comprising Theory & Practical | 5 | 15 | 50 | 30 |
| Courses Comprising Only Theory | 5 | 15 | 80 | |
| Courses Comprising Only Practical | 5 | 15 | | 80 |

**Comprehensive Exam Pattern:** Written Exam followed by Oral Exam

**(i.) Written Exam:**

M.Sc. (Agri.): 2 papers (1 Major + 1 Supporting & Optional subject).

Ph. D.: 3 papers (2 Major + 1 Supporting & Optional subject).

Maximum marks: 100 each

Paper setting: Internal under the Chairmanship of HOD.

Evaluation: Internal under the Chairmanship of HOD.

Qualifying marks:

M.Sc. (Ag): 60% individually, Ph.D.: 65% individually.

**(ii.) Oral Examination: 100 marks**

M.Sc. (Agri.): After qualifying the Written Exam, the Oral Exam should be conducted by the Students' Advisory Committee in presence of HOD.

Ph.D.: Exam will be conducted by External Examiner.

Grading of the Comprehensive Exam. (M.Sc. &Ph.D.): Satisfactory/ Not Satisfactory.

# COURSE CONTENTS: M.Sc. (Agri.) GENETICS AND PLANT BREEDING

| GPB 511 | PRINCIPLES OF GENETICS | 3 (3+0) |
|---|---|---|

**WHY THIS COURSE?**

Genes are the backbone of all crop improvement activities. Their chemical structure and physical inheritance are pivotal for any breeding program. Therefore, it has to be the core course for master's degree in Genetics & Plant Breeding.

**AIM OF THE COURSE**

This course is aimed at understanding the basic concepts of inheritance of genetic traits, helping students to develop their analytical, quantitative and problem-solving skills from classical to molecular genetics.

**COURSE OUTCOME**

After passing out this course the student will be able to know the difference between the genotype and phenotype, can carry study on inheritance and also know the role of DNA and RNA in genotypic manifestation of characters.

**THEORY**

**UNIT-I:** Beginning of genetics, early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance; Multiple alleles, Gene interactions, Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

**UNIT-II:** Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.

**UNIT-III:** Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis, fine structure of gene, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters; Regulation of gene activity in prokaryotes and eukaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression, RNA editing.

**UNIT-IV:** Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; MicroRNAs (miRNAs).

**UNIT-V:** Genomics and proteomics; metagenomics; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders.

**PRACTICAL**

- Laboratory exercises in probability and chi-square;
- Demonstration of genetic principles using laboratory organisms;
- Chromosome mapping using three-point test cross;
- Tetrad analysis; Induction and detection of mutations through genetic tests;
- DNA extraction and PCR amplification;
- Electrophoresis: basic principles and running of amplified DNA;
- Extraction of proteins and isozymes;
- Use of Agrobacterium mediated method and Biolistic gun; practical demonstrations:
- Detection of transgenes in the exposed plant material;
- Visit to transgenic glasshouse and learning the practical considerations.

**TEACHING METHODS**

- Power point presentation,
- Chalk and Board
- Smart board
- Lectures,

- Assignments, quiz,
- Group tasks, student's presentations

**SUGGESTED READINGS**


1. Daniel, L. H. & Maryellen, R. (2011). Genetics: "Analysis of Genes and Genomes". Daniel Hart.
2. Gardner, E. J. & Snustad, D. P. 1991. Principles of Genetics. John Wiley & Sons. 8th ed. 2006.
3. Klug, W. S. & Cummings, M. R. (2003). Concepts of Genetics. Peterson Edu. Pearson Education India; 10th ed.
4. Lewin, B. (2008). Genes XII. Jones & Bartlett Publ. (International Edition) Paperback, 2018.
5. Russell, P. J. (1998). Genetics. The Benzamin/Cummings Publ. Co.
6. Snustad, D. P. & Simmons MJ (2006). Genetics. 4th ed. John Wiley & Sons. 6th Edition International Student Version edition.
7. Singh B. D. (2009). Genetics. Kalyani Publishers (2nd Revised Edition).
8. Stansfield, W. D. (1991). Genetics. Schaum Outline Series McGraw Hill.
9. Strickberger, M. W. (2005). Genetics (III Ed). Prentice Hall, New Delhi, India; 3rd ed., 2015.
10. Tamarin, R. H. (1999). Principles of Genetics. Wm. C. Brown Publs., McGraw Hill Education; 7th edition.
11. Uppal, S., Yadav, R., Singh, S. & Saharan, R. P. (2005). Practical Manual on Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar.


## GPB 512 PRINCIPLES OF PLANT BREEDING 3 (2+1)

**WHY THIS COURSE?**

Development of plant variety is the ultimate aim of any plant breeding program. A post graduate in the subject of agriculture must know what are the different selection methods, techniques and related crop improvement strategies. Further, knowledge of genetic resources, evolution and their role in development of noble varieties is the need of the hour.

**AIM OF THE COURSE**

To impart theoretical knowledge and practical skills about plant breeding objectives, genetic consequences, breeding methods for crop improvement.

**COURSE OUTCOME**

The knowledge of this course will enable the student to know breeding methods, different hybridization techniques for genomic reshuffling. The course will also acquaint the student with importance of floral biology, mutation breeding and participatory plant breeding, *etc*.

**THEORY**

**UNIT-I:** Early Plant Breeding; Accomplishments through plant breeding; Objectives of plant breeding; Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity and its significance. Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.

**UNIT-II:** Genetic basis of breeding: self and cross pollinated crops including mating systems and response to selection; Nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding.

**UNIT-III:** Pure line theory, pure line and mass selection methods: pedigree, bulk, backcross, single seed descent and multiline breeding; Population breeding in self-pollinated crops with special reference to diallel selective mating; Transgressive breeding.

**UNIT-IV:** Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; $S_1$ and $S_2$ progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreeds, breeding approaches for improvement of inbreeds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreeds; Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

**UNIT-V:** Breeding methods in asexually/clonally propagated crops, clonal selection.

**UNIT-VI:** Special breeding techniques: Mutation breeding, Breeding for abiotic and biotic stresses; Concept of plant ideotype and its role in crop improvement, concept of MAS, concept of polyploidy and wide hybridization, doubled haploidy.

**UNIT-VII:** Cultivar development: testing, release and notification; maintenance breeding; Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

**PRACTICAL**

- Floral biology in self and cross pollinated species;
- Selfing and crossing techniques;
- Selection methods in segregating populations and evaluation of breeding material;
- Analysis of variance (ANOVA);
- Estimation of heritability and genetic advance;
- Estimation of heterosis;
- Estimation of inbreeding depression;
- Maintenance of experimental records;
- Learning techniques in hybrid seed production using male-sterility in field crops;
- Prediction of performance of double cross hybrid.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures,
- Assignments, quiz,
- Group tasks, student's presentations

**SUGGESTED READINGS**


1. Allard, R. W. (1981). Principles of Plant Breeding. John Wiley & Sons.
2. Chahal, G. S. and Gossal SS (2002). Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches. Narosa Publishing.
3. Chopra, V. L. (2004). Plant Breeding. Oxford & IBH.
4. George, A. (2012). Principles of Plant Genetics and Breeding. John Wiley & Sons.
5. Gupta, S. K. (2005). Practical Plant Breeding. *Agribios*.
6. Jain, H. K. and Kharakwal, M. C. (2004). Plant Breeding –Mendelian to Molecular Approach, Narosa Publications New Delhi.
7. Roy, D. (2003). Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ. House.
8. Sharma, J. R. (2001). Principles and Practice of Plant Breeding. Tata McGraw Hills.
9. Sharma, J. P. (2010). Principles of Vegetable Breeding. Kalyani Publ, New Delhi.
10. Simmonds, N. W. (1990). Principles of Crop Improvement. English Language Book Society.
11. Singh, B. D. (2006). Plant Breeding. Kalyani Publ.
12. Singh, S. & Pawar, I. S. (2006). Genetic Bases and Methods of Plant Breeding. CBS.


## GPB 513 FUNDAMENTALS OF QUANTITATIVE GENETICS 3 (2+1)

**WHY THIS COURSE?**

Yield and quality characters are controlled by many genes and show the quantitative inheritance. If one has to go for improvement even for the components characters the knowledge of this course is very essential.

**AIM OF THE COURSE**

To impart theoretical knowledge and computation skills regarding components of variation and variances, scales, mating designs and gene effects.

**COURSE OUTCOME**

After studying this course, the student will be equipped with the knowledge of additive dominance and epistatic gene action. He will also be introduced with the various designs for analysis of genotypic and phenotypic variance and QTL mapping.

**THEORY**

**UNIT-I:** Introduction and historical background of quantitative genetics; Multiple factor hypothesis; Qualitative and quantitative characters; Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic; Nature of gene action- additive, dominance and epistatic; linkage effect. Principles of analysis of variance and linear model; Expected variance components, Random and fixed effect model, Comparison of means and variances for significance.

**UNIT-II:** Designs for plant breeding experiments- principles and applications; Variability parameters; concept of selection; simultaneous selection modes and selection of parents, MANOVA

**UNIT-III:** Association analysis- Genotypic and phenotypic correlation, Path analysis; Discriminate function and principal component analysi; Genetic divergence analysis- Metroglyph and $D^2$, Generation mean analysis; Parent progeny regression analysis

**UNIT-IV:** Mating designs- classification, Diallel, Partial diallel, L x T, NCDs, and TTC; Concept of combining ability and gene action, G x E interaction-Adaptability and stability; Methods and models for stability analysis; Basic models- principles and interpretation, Bi-plot analysis.

**UNIT-V:** QTL mapping, Strategies for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis; Markers, Marker assisted selection and factors influencing the MAS, Simultaneous selection based on marker and phenotype.

**PRACTICAL**

- Analysis and interpretation of variability parameters, Analysis and interpretation of Index score and Metroglyph;
- Clustering and interpretation of $D^2$ analysis;
- Genotypic and phenotypic correlation analysis and interpretation;
- Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation;
- A, B and C Scaling test;
- L x T analysis and interpretation, QTL analysis;
- Use of computer packages- Diallel analysis, GxE interaction and stability analysis.

**TEACHING METHODS**

- Power point presentation,
- Chalk and Board,
- Smart board,
- Lectures,
- Assignments/ quiz,
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Bos, I. & Caligari, P. (1995). Selection Methods in Plant Breeding. Chapman & Hall.
2. Falconer. D. S. and Mackay, J. (1998). Introduction to Quantitative Genetics (3rd Ed.).ELBS/ Longman, London.
3. Mather, K. & Jinks, J. L. (1985). Biometrical Genetics (3rd Ed.). Chapman & Hall, London.
4. Nandarajan, N. & Gunasekaran, M. (2008). Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publishers.
5. Naryanan, S. S. & Singh, P. (2007). Biometrical Techniques in Plant Breeding. Kalyani Publ.
6. Roy, D. (2000). Plant Breeding: Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi.
7. Sharma, J. R. (2006). Statistical and Biometrical Techniques in Plant Breeding. New Age International Pvt. Ltd.
8. Singh, P. & Narayanan, S. S. (1993). Biometrical Techniques in Plant Breeding. Kalyani Publ.
9. Singh, R. K. & Chaudhary, B. D (1987). Biometrical Methods in Quantitative Genetic analysis. Kalyani Publ.
10. Weir, D. S. (1990). Genetic Data Analysis- Methods for Discrete Population Genetic Data. Sinauer Associates.
11. Wricke, G. & Weber, W. E. (1986). Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.
12. www.iasri.icar.gov.in or www.hau.ac.in /OPstat

## GPB 521 PRINCIPLES OF CYTOGENETICS 3 (2+1)

**WHY THIS COURSE?**

The very purpose of this course is to acquaint the students with cell cycle and architecture of chromosome in prokaryotes and eukaryotes, special types of chromosomes, techniques for karyotyping. This course aims to impart knowledge of variations in chromosomes numbers and their structures. It acquaints the students for the production and use of haploids, apomictic populations and their role in genetics and breeding.

**AIM OF THE COURSE**

To provide insight into structure and functions of chromosomes, chromosome mapping, polyploidy and cytogenetic aspects of crop evolution.

**COURSE OUTCOME**

The course will provide full knowledge to the student on the various procedures linked with cell development and chromosome structure and function. This course will also enable student how to tailor and utilize the variation in chromosome number and structures in the development and synthesis of new species and varieties.

**THEORY**

**UNIT-I:** Cell cycle and architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; artificial chromosome construction and its uses; Special types of chromosomes; Variation in chromosome structure: Evolutionary significance; Introduction to techniques for karyotyping; Chromosome banding and painting- *in situ* hybridization and various applications.

**UNIT-II:** Structural and numerical variations of chromosomes and their implications; Symbols and terminologies for chromosome numbers, euploidy, haploids, diploids and polyploids; Utilization of aneuploids in gene location; Variation in chromosome behaviour, somatic segregation and chimeras, endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations, balanced lethal and chromosome complexes; Inter-varietal chromosome substitutions.

**UNIT-III:** Fertilization barriers in crop plants at pre-and post-fertilization levels; *In vitro* techniques to overcome the fertilization barriers in crops; Polyploidy- Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid *vs.* allopolyploids; Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer; Alien addition and substitution lines, creation and utilization; Apomixis, evolutionary and genetic problems in crops with apomixes.

**UNIT-IV:** Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale, brassica and cotton); Hybrids between species with same chromosome number, alien translocations; Hybrids between species with different chromosome number; Gene transfer using amphidiploids, bridge species.

**UNIT-V:** Chromosome manipulations in wide hybridization; case studies; Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

**PRACTICAL**

- Learning the cytogenetical laboratory techniques: various chemicals to be used for fixation, dehydration, embedding, staining, cleaning *etc.*;
- Microscopy: various types of microscopes;
- Preparing specimen for observation;
- Fixative preparation and fixing specimen for light microscopy studies in cereals;
- Studies on mitosis and meiosis in crop plants;
- Using micrometres and studying the pollen grain size in various crops; Pollen germination *in vivo* and *in vitro*;
- Demonstration of polyploidy.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board

- Smart board
- Lectures
- Assignments/ quiz,
- Group tasks, student's presentations.

**SUGGESTED READINGS**


1. Becker, K. & Hardin, J. (2004). World of the Cell. 5th Ed. Pearson Edu. 9th edition.
2. Carroll, M. (1989). Organelles. The Guilford Press.
3. Charles, B. (1993). Discussions in Cytogenetics. Prentice Hall Publications.
4. Darlington, C. D. & LaCour, L. F. (1969). The Handling of Chromosomes. George Allen & Unwin Ltd.
5. Elgin, S.C.R (1995). Chromatin Structure and Gene Expression. IRL Press, Oxford.
6. Khush GS (1973). Cytogenetics of aneuploids. Elsevier. 1st edition.
7. Gupta, P. K. and Tsuchiya, T. (1991). Chromosome Engineering in Plants: Genetics, Breeding and Evolution. Part A.
8. Gupta, P. K. (2010). Cytogenetics. Rastogi Pubishers.
9. Johannson, D. A. (1975). Plant Micro technique. McGraw Hill.
10. Karp, G. (1996). Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons
11. Roy, D. 2009. Cytogenetics. Alpha Science Intl Ltd.
12. Schulz, S. J. (1980). Cytogenetics - Plant, animals and Humans. Springer.
13. Sharma, A. K. and Sharma, A. (1988). Chromosome Techniques: Theory and Practice. Butterworth- Heinemann publisher 2014 3rd edition.
14. Singh, R. J. (2016). Plant Cytogenetics. 3rd Edition. CRC Press.
15. Sumner, A. T. (1982). Chromosome Banding. Unwin Hyman Publ. 1st edition, Springer Publi.
16. Swanson, C. P. (1960). Cytology and Cytogenetics. Macmillan & Co.


## GPB 522 BREEDING FOR QUALITY AND SPECIAL TRAITS 3 (2+1)

**WHY THIS COURSE?**

Quality consciousness is growing in the society and only quality products are in demand in the market so has to be the new varieties. This course acquaints breeding for grain quality parameters in field crops. It will also teach about the genetic engineering protocols for quality improvement: Biofortification in crops and Nutritional genomics and Second generation transgenics.

**AIM OF THE COURSE**

To provide insight into recent advances in improvement of quality traits in cereals, millets, legumes, oilseeds, forage and industrial crops using conventional and modern biotechnological approaches.

**COURSE OUTCOME**

The knowledge of this course will expose the student to know about various conventional and genetic engineering techniques for the improvement of quality characters in agricultural and horticultural field crops.

**THEORY**

**UNIT-I:** Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors; Nutritional improvement -A human perspective.

**UNIT-II:** Breeding for grain quality parameters in rice and its analysis; Golden rice and aromatic rice; Breeding strategies, achievements and application in Indian context; Molecular basis of quality traits and their manipulation in rice; Post harvest manipulation for quality improvement; Breeding for baking qualities in wheat, characters to be considered and breeding strategies, molecular and cytogenetic manipulation for quality improvement in wheat.

**UNIT-III:** Breeding for quality improvement in sorghum, pearl millet, barley and oats; Quality protein maize, specialty corns, concept and breeding strategies; Breeding for quality improvement in important forage crops for stay green traits; Genetic resource management for sustaining nutritive quality in crops.

**UNIT-IV:** Breeding for quality in pulses –chickpea, pigeonpea, mungbean and black gram cooking quality; Breeding for quality in oilseeds -groundnut, mustard, soybean, sesame, sunflower and minor oilseeds; Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality improvement in cotton. Breeding for quality improvement in Sugarcane, potato.

**UNIT-V:** Genetic engineering protocols for quality improvement: Achievements made; Biofortification in crops; Classification and importance, Nutritional genomics and Second generation transgenics.

**PRACTICAL**

- Grain quality evaluation in rice; Correlating ageing and quality improvement in rice;
- Quality analysis in millets;
- Estimation of anti-nutritional factors like tannins in different varieties/hybrids; A comparison;
- Quality parameters evaluation in wheat, pulses and oilseeds;
- Evaluation of quality parameters in cotton, sugarcane and potato;
- Value addition in crop plants;
- Post-harvest processing of major field crops;
- Quality improvement in crops through tissue culture techniques;
- Evaluating the available populations like RIL, NIL *etc.* for quality improvement using MAS procedures;
- Successful example of application of MAS for quality trait in rice, mustard, maize *etc.*

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Chahal, G. S. and Ghosal, S. S. (2002). Principles and procedures of plant breeding - Biotechnological and Conventional approaches, Narosa Publications.
2. Chopra, V. L. (1997). Plant Breeding. Oxford & IBH 2018.
3. FAO (2001). Speciality Rice of the World - Breeding, Production and Marketing. Oxford & IBH.
4. Ghosh, P. (2004). Fiber Science and Technology. Tata McGraw Hill.
5. Gupta, S. K. (2007). Advances in Botanical Research Vol. 45 Academic Press USA.
6. Hay, R. K. (2006). Physiology of Crop Yield. 2nd Ed. Blackwell.
7. Nigam, J. (1996). Genetic Improvement of Oilseed Crops. Oxford & IBH.
8. Singh, B. D. (1997). Plant Breeding. Kalyani Publ.
9. Singh, R. K., Singh, U. K. & Khush, G. S. (2000). Aromatic Rices. Oxford & IBH.

## GPB 523 MUTAGENESIS AND MUTATION BREEDING 3 (2+1)

**WHY THIS COURSE?**

The knowledge of this course will enable the students to learn about mutation, various methods of inducing mutations and their utilization in plant breeding. It will also give in depth knowledge about genomics, allele mining, TILLING, *etc.* and their utilization in crop improvement programmes.

**AIM OF THE COURSE**

To impart the knowledge about general principles of mutagenesis for crop improvement and various tests/methods for detection of mutations.

**COURSE OUTCOME**

This course will make the student well versed with the process of mutation and its use in crop improvement. This course will also give in depth knowledge of mutations in genomics, allele mining and TILLING.

**THEORY**

**UNIT-I:** Mutation and its history, nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre- and post-adaptive mutations; Detection of mutations. Paramutations in crops plants.

**UNIT-II:** Mutagenic agents: physical– radiation types and sources: Ionizing and non-ionizing radiations. Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects– RBE and LET relationships; Effect of mutations on DNA– repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects; Dosimetry- Objects and methods of treatment; Factors influencing mutation: dose rate, acute *vs.* chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects; Radiation sensitivity and modifying factors: External and internal sources– Oxygen, water content, temperature and nuclear volume.

**UNIT-III:** Chemical mutagens: Classification– base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action; Dose determination and factors influencing chemical mutagenesis; Treatment methods using physical and chemical mutagens, Combination treatments; other causes of mutation-direct and indirect action, comparative evaluation of physical and chemical mutagens.

**UNIT-IV:** Observing mutagen effects in $M_1$ generation: plant injury, lethality, sterility, chimeras *etc.*; Observing mutagen effects in $M_2$ generation; Estimation of mutagenic efficiency and effectiveness, spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose; pleiotropy and linkage *etc.*; Individual plant based mutation analysis and working out effectiveness and efficiency in $M_3$ generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies.

**UNIT-V:** Use of mutagens in creating oligogenic and polygenic variations– Case studies; *In vitro* mutagenesis– Callus and pollen irradiation; Handling of segregating $M_2$ generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement *etc.*) in different crops; Procedures for micromutations breeding/ polygenic mutations; Achievements of mutation breeding varieties released across the world, problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING

**PRACTICAL**

- Precautions on handling of mutagens; Dosimetry- Studies of different mutagenic agents: Physical mutagens and Chemical mutagens;
- Learning on Radioactivity- Production source and isotopes at BRIT, Trombay, Learning about gamma chamber;
- Radiation hazards: Monitoring- safety regulations and safe transportation of radioisotopes, visit to radio isotope laboratory; learning on safe disposal of radioisotopes;
- Hazards due to chemical mutagens- Treating the plant propagules at different doses of physical and chemical mutagens;
- Procedures in combined mutagenic treatments;
- Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature;
- Study of $M_1$ generation– Parameters;
- Study of $M_2$ generation– Parameters;
- Mutation breeding in cereals and pulses- achievements made and an analysis;
- Mutation breeding in oilseeds and cotton- achievements and opportunities;
- Mutation breeding in forage crops and vegetatively propagated crops;
- Procedure for detection of mutations for polygenic traits in $M_2$ and $M_3$ generations.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**


1. Alper, T. (1979). Cellular Radiobiology. Cambridge University Press, London.
2. Chadwick, K. H. & Leenhouts, H. P (1981). The Molecular Theory of Radiation Biology. Springer-Verlag.
3. Cotton, R., Edkin, E. & Forrest, S. (2000). Mutation Detection: A Practical Approach. Oxford University Press.
4. International Atomic Energy Agency (1970). Manual on Mutation Breeding. International Atomic Energy Agency, Vienna, Italy.
5. Shu, Q. Y., Forster, B. P. and Nakagawa, N. (2012). Plant Mutation Breeding and Biotechnology. Gutecnberg Press Ltd. Rome Italy ISBN:978-925107-022-2 (FAO).
6. Sharma, A. K. (2014). Crop Improvement and Mutation Breeding. Scientific Publishers, Jodhpur.
7. Singh, B. D. (2003). Genetics. Kalyani Publishers.
8. Strickberger, M. W. (2005). Genetics. 3rd Ed. Prentice Hall.


## GPB 524 CROP BREEDING-II (*RABI* CROPS) 3 (2+1)

**WHY THIS COURSE?**

Botanical features, reproductive systems, genetics involved and important breeding techniques are essential to undertake any crop improvement programme. This course is designed for important/ major Rabi field crops.

**AIM OF THE COURSE**

To provide insight into recent advances in improvement of *Rabi* cereals, legumes, oilseeds, fibre and vegetative propagated crops using conventional and modern biotechnological approaches.

**COURSE OUTCOME**

After completion of this course the student will be able to know about the different breeding methods and genetics of major Rabi field crops.

**THEORY**

**UNIT-I**

**Wheat:** Origin, evolution, mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*, breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

**Oats:** Origin, evolution, mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*, breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

**Barley:** Origin, evolution, centre of origin, mode of reproduction, chromosome number; Genetics-cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*, breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement

**UNIT-II**

**Chickpea:** Origin, evolution mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*, breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

**Other pulses: Lentil, field pea, Rajma, Horse gram:** Origin, evolution, mode of reproduction, chromosome number; Genetics. cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*, breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

**UNIT-III**

**Rapeseed and Mustard:** Origin, evolution, mode of reproduction, chromosome number; Genetics-cytogenetics and genome relationship; Breeding objectives; yield, quality characters, biotic and abiotic stress resistance *etc.*, breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Oil quality, Improvement for oil quality.

**Sunflower, Safflower:** Origin, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*, breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement

**UNIT-IV**

**Mesta and minor fibre crops:** Origin, mode of reproduction, chromosome number; Genetics-cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*, breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

**Forage crops:** Origin, evolution mode of reproduction, chromosome number; Genetics-cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*, breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

**UNIT-V**

**Seed spices:** Origin, evolution, mode of reproduction, chromosome number; Genetics-cytogenetics and genome relationship; Breeding objectives : yield, quality characters, biotic and abiotic stress resistance *etc.*, breeding approaches, introgression of alien gene(s) (if required), , biotic and abiotic stress resistance, scope of heterosis breeding, released varieties, examples of MAS used for crop improvement.

**PRACTICAL**

- Floral biology, emasculation and pollination techniques in wheat, oats, barley, chickpea, rajma, rapeseed mustard, sunflower;
- Study of range of variation for yield and yield components;
- Study of segregating populations in cereal, pulses and oilseed crops;
- Use of descriptors for cataloguing; Learning on the crosses between different species;
- Trait based screening for stress resistance;
- Learning on the Standard Evaluation System (SES) and descriptors;
- Use of software for database management and retrieval.

**TEACHING METHODS**

- Power point presentation,
- Chalk and Board
- Smart board
- Lectures, Assignments, quiz,
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Agarwal, R. L. (1996). Identifying Characteristics of Crop Varieties. Oxford & IBH.
2. Bahl, P. N. & Salimath, P. M. (1996). Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I. Pulses and Oilseeds. Oxford & IBH.
3. Gupta, S. K. (2012). Technological Innovations in Major World Oil crops. Vol. I. Springer, USA.
4. Gupta, S. K. (2012).Technological Innovations in Major World Oil crops. Vol. II. Springer, USA.
5. Gupta, S. K. (2016). Breeding of Oilseed Crops for Sustainable Production. Acad. Press, USA.
6. Kannaiyan, S., Uthamasamy, S., Theodore, R. K. & Palaniswamy, S. (2002). New Dimensions and Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU, Coimbatore.
7. Parthasarathy, V. A. (2017). Spices and Plantation Crops Vol.1 (Part A) Breeding of Horticultural Crops Vol.1 (Part-B).
8. Poehlman, J. M. (1987). Breeding of Field Crops. AVI Publishing Co. Inc. East Post Connectcut, USA.
9. Ram, H. H. & Singh, H. G. (1993). Crop Breeding and Genetics. Kalyani Publisher, New Delhi.

10. Sharma, A. K. (2005). Breeding Technology of Crop Plant. Yesh Publishing House,
11. Sing,h H. G., Mishra, S. N., Singh, T. B., Ram, H. H. & Singh, D. P. (Eds.) 1994. Crop Breeding in India. International Book Distributing Co.
12. Slafer, G. A. (Ed.). 1994. Genetic Improvement of Field Crops. Marcel Dekker.
13. Walden, D. B. (1978). Maize Breeding and Genetics. John Wiley & Sons.

## GPB 525 BREEDING FOR VEGETABLE CROPS 3 (2+1)

**WHY THIS COURSE?**

This course enables the students to learn about breeding objectives, methodologies and genetics involved for the improvement of major vegetable crops.

**AIM OF THE COURSE**

To educate about principles and practices adopted for breeding of vegetable crops.

**COURSE OUTCOME**

After completion of this course the students will be able to know about the different breeding methods and genetics of major vegetable crops.

**THEORY**

**UNIT-I:** Breeding for Leafy vegetables: amaranth, chenopods and lettuce.

**UNIT-II:** Breeding for Cucurbits: Gourds, melons, pumpkins and squashes.

**UNIT-III:** Breeding for Solanaceae: Potato and tomato, eggplant, hot pepper, sweet pepper.

**UNIT-IV:** Breeding for Cole crops: cabbage, cauliflower, broccoli and knolkhol. Breeding for Root vegetables: carrot, beetroot, radish, sweet potato and tapioca.

**UNIT-V:** Breeding for other vegetable crops: Peas, beans, onion, garlic and okra.

**PRACTICAL**

- Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm;
- Hybridization and handling segregating generations;
- Induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops;
- Hybrid seed production of vegetable crops in bulk;
- Screening techniques for insect-pests, disease and environmental stress resistance in vegetable crops;
- Demonstration of sib-mating and mixed population;
- Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques;
- Visit to breeding blocks, MAS for incorporating traits governed by major and polygenes.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Allard, R. W. (1999). Principles of Plant Breeding. John Wiley & Sons.
2. Fageria, M. S., Arya, P. S. & Choudhary, A. K. (2000). Vegetable Crops: Breeding and Seed Production. Vol.-I. Kalyani Publishers.
3. Kalloo, G. (1988). Vegetable Breeding. Vols. I-III. CRC Press.
4. Kalloo, G. (1998). Vegetable Breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
5. Peter, K. V. & Pradeep, K. T. (2008). Genetics and Breeding of Vegetables. ICAR.
6. Rai, N. & Rai, M. (2006). Heterosis Breeding in Vegetable Crops. New India Publication Agency.
7. Ram, H. H. (2005). Vegetable Breeding-Principles & Practices. Kalyani Publishers.
8. Sharma, J. P. (2010). Principles of Vegetable Breeding. Kalyani Publishers, New Delhi.
9. Singh, B. D. (1983). Plant Breeding. Kalyani Publishers.

## GPB 526 BREEDING FOR FRUIT CROPS 3 (2+1)

**WHY THIS COURSE?**

This course is aimed to educate the students about the breeding strategies and avenues in Fruit crops.

**AIM OF THE COURSE**

To educate students about principles and practices adopted for breeding of fruit crops.

**COURSE OUTCOME**

After completion of this course the students will be able do the breeding of fruit crops through various conventional and biotechnological methods besides mutation breeding.

**THEORY**

**UNIT-I:** Fruit crop breeding: History, importance of fruit breeding, centres of diversity, distribution, domestication and adaptation of commercially important fruits.

**UNIT-II:** Issues in fruit crop breeding: heterozygosity, polyploidy, polyembryony, parthenocarpy and seed lessness, incompatibility & sterility systems.

**UNIT-III:** Apomixis: merits and demerits, types, variability for economic traits, role of genetic engineering and biotechnology in improvement of fruit crops.

**UNIT-IV:** Crop improvement in Mango, Banana, Citrus, Grapes, Papaya, Sapota and Pomegranate, Pine apple & Guava, Apple and other Rosaceous crops and region specific fruit crops.

**PRACTICAL**

- Germplasm documentation;
- Floral biology of mango, guava, citrus, grape, pomegranate, pollen viability in major fruit crops;
- Pollen germination to study time of anthesis and stigma receptivity;
- Hybridization technique in important fruit crops, hybrid seed collection and raising;
- Colchicine treatment for induction of polyploidy;
- Exposure to resistance breeding & screening techniques;
- Mutation breeding practices raising and evaluation of segregating populations;
- Use of mutagens to induce mutations and polyploidy,
- Visit to Biotechnology Lab & study of *in vitro* breeding techniques

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**


1. Bhojwani, S. S. and Razdan, M. K. 2006. Plant Tissue Culture -Theory and Practice. Elsevier Publication, Amesterdam.
2. Chadha, K. L. and Pareek, O. P. (1996). (Eds.). Advances in Horticulture. Vol. I to IV. Malhotra Publ. House, New Delhi.
3. Chadha, K. L. and Shikhamany, S. D. (1999). The Grape: Improvement, Production and Post Harvest Management. Malhotra Publ. House, New Delhi.
4. Janick, and Moore, J. N. (1996). Advances in Fruit Breeding, AVI Pub., USA.
5. Janick, J. and Moore, J. N. (1996). Fruit Breeding. Vols. I to III. John Wiley & Sons.
6. Kumar, N. (2006). Breeding of Horticultural Crops -Principles and Practices. New India Publishing Agency, New Delhi.
7. Moore, J. N. and Janick, J. (1996). Methods in Fruit Breeding. Purdue University Press, South Campus Court D., USA
8. Parthasarathy, V. A., Bose, T. K., Deka, P. C., Das, P., Mitra, S. K. and Mohanadas, S. (2001). Biotechnology of Horticultural Crops. Vols. I-III. Naya Prokash, Kolkata.
9. Ray, P. K. (2002). Breeding of Tropical and Sub-tropical Fruits. Narosa Publishing House, New Delhi.
10. Simmonds, N. W. (1976). Evolution of Crop Plants, Orient Longman, London.

## GPB 527 BREEDING FOR ORNAMENTAL CROPS 3(2+1)

**WHY THIS COURSE?**

The course will impart knowledge to student about breeding of Ornamental Crops through conventional and biotechnological interventions.

**AIM OF THE COURSE**

To educate about principles and practices adopted for breeding of ornamental crops.

**COURSE OUTCOME**

After completion of this course the students will be able to do the breeding of ornamental crops by conventional breeding and biotechnological methods and to know the genetics of major ornamental crops.

**THEORY**

**UNIT-I:** History of improvement of ornamental plants; Centre of origin of ornamental crop; Objectives and techniques in ornamental plant breeding.

**UNIT-II:** Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops viz., rose, jasmine, chrysanthemum, tuberose, gerbera, gladiolus, dahlia, lilium, gaillardia, petunia, bougainvillea, pansy, marigold, geranium, antirrhinum, china aster, orchids, antirrhinum, carnation, hibiscus *etc.*

**UNIT-III:** Development of promising cultivars of important ornamental and flower crops; Role of Heterosis and its exploitation, production of F1 hybrids and utilization of male sterility.

**UNIT-IV:** Production of open pollinated seeds, harvesting, processing and storage of seeds; Seed certification.

**PRACTICAL**

- Study of floral biology and pollination in important species and cultivars of ornamental crops;
- Techniques of inducing polyploidy and mutation;
- Production of pure and hybrid seed;
- Methods of breeding suited to seed propagated plants;
- Polyploidy and mutations to evolve new varieties;
- Breeding methods for biotic and abiotic stresses;
- Visit to research institutes involved in ornamental crop breeding.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Alexander, V. (2002). Breeding for ornamentals: Classical and Molecular Approaches. Kluwer Academic Publishers, London.
2. Allard, R. W. (1999). Principles of Plant Breeding. John Wiley & Sons. INC. New York.
3. Bhattacharjee, S. K. and De, L. C. (2003). Advanced Commercial Floriculture Vol.-I. Aavishkar Publishers & Distributors, Jaipur.
4. Bose, T. K. and Yadav, L. P. (2003). Commercial Flowers. Naya Prokash Publishers, Kolkata.
5. Chadha, K. L. and Bhattacharjee, S. K. Advances in Horticulture Vol.-12, Malhotra Publishing House, New Delhi.
6. Mc Donald, M. B. and Kwong F. Y. (2005). Flower Seeds Biology and Technology, CABI Publishing, Oxford Shire, UK.
7. Watts, L. (1980). Flower and Vegetable Plant Breeding. Grower Books.

## GPB 528 BREEDING FOR STRESS RESISTANCE AND CLIMATE CHANGE 3 (2+)

**WHY THIS COURSE?**

Climate change is a big challenge to sustain higher crop productivity and nutritional quality. Concept of breeding for stress tolerance and development of hybrids/ varieties for climate change is of prime importance in plant breeding. Therefore this course is essential for budding plant breeders.

**AIM OF THE COURSE**

To apprise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress tolerant varieties.

**COURSE OUTCOME**

After completion of this course the student will be able to well verse with the stress and its causes. This will enable the students for the development of RIL, NIL *etc.* for pest resistance and Use of standard MAS procedures.

**THEORY**

**UNIT-I:** Concept and impact of climatic change; Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses –major pests and diseases of economically important crops.

**UNIT-II:** Concepts of resistance to insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions -Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defence mechanisms against viruses and bacteria.

**UNIT-III:** Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants; Quantitative resistance/ adult plant resistance and slow rusting resistance; Classical and molecular breeding methods -Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data –Gene pyramiding methods and their implications.

Classification of abiotic stresses -Stress inducing factors, moisture stress/ drought and water logging & submergence; Acidity, salinity/ alkalinity/ sodicity; High/ low temperature, wind, *etc*; Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

**UNIT-IV:** Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging & submergence, high and low/ freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton *etc.*; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in soil, water and environment.

**UNIT-V:** Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

**PRACTICAL**

- Understanding the climatological parameters and predisposal of biotic and abiotic stress factors-ways of combating them for diseases caused by fungi and bacteria;
- Symptoms and data recording: use of MAS procedures;
- Phenotypic screening techniques for sucking pests and chewing pests –Traits to be observed at plant and insect level;
- Phenotypic screening techniques for nematodes and borers -Ways of combating them;
- Evaluating the available populations like RIL, NIL *etc.* for pest resistance;
- Use of standard MAS procedures, Breeding strategies -Weeds –ecological, environmental impacts on the crops;
- Breeding for herbicide resistance;

- Screening crops for drought and flood resistance; factors to be considered and breeding strategies;
- Screening varieties of major crops for acidity and alkalinity -their effects and breeding strategies.
- Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations

**SUGGESTED READINGS**


1. Blum, A. (1988). Plant Breeding for Stress Environments. CRC Press.
2. Christiansen, M. N. & Lewis, C. F. (1982). Breeding Plants for Less Favourable Environments. Wiley International.
3. Fritz, R. S. & Simms, E. L. (Eds.). 1992. Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics. The University of Chicago Press.
4. Li, P. H. & Sakai, A (1987). Plant Cold Hardiness. Liss, New York Springer.
5. Luginpill, P. (1969). Developing Resistant Plants -The Ideal Method of Controlling Insects. USDA, ARS, Washington DC.
6. Maxwell, F. G. & Jennings, P. R. (Eds.). 1980. Breeding Plants Resistant to Insects. John Wiley & Sons, Wiley-Blackwell.
7. Roberto, F. (2018. Plant Breeding for Biotic & Abiotic Stress Tolerance. Sringer.
8. Russel, G. E. (1978). Plant Breeding for Pest and Disease Resistance. Butterworths.
9. Sakai, A. & Larcher, W. (1987). Frost Survival in Plants. Springer-Verlag.
10. Singh, B. D. (2006). Plant Breeding. Kalyani Publ.
11. Turener, N. C. & Kramer, P. J. (1980). Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons.
12. Van der Plank, J. E. (1982). Host-Pathogen Interactions in Plant Disease. Academic Press.


## GPB 531 MOLECULAR BREEDING AND BIOINFORMATICS 3 (2+1)

**WHY THIS COURSE?**

The course will provide deep knowledge to the students on genotyping and kinds of markers including biochemical and molecular, mapping populations, allele mining. This will also add ways to perform marker-assisted selection and gene pyramiding to evolve superior varieties.

**AIM OF THE COURSE**

To impart knowledge and practical skills to use innovative approaches and Bioinformatics in Plant Breeding.

**COURSE OUTCOME**

The knowledge of this course will enable the student to know about various molecular tools and approaches for genotyping and marker assisted breeding, intellectual property rights, bioinformatics tools and their uses in crop improvement.

**THEORY**

**UNIT-I:** Genotyping; Biochemical and Molecular markers; Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs *etc.*), Functional markers; Mapping populations ($F_2$s, back crosses, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits; Statistical tools in marker analysis.

**UNIT-II:** Allele mining; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants; Marker-assisted backcross breeding for rapid introgression; Genomics-assisted breeding; Generation of EDVs; Gene pyramiding.

**UNIT-III:** Introduction to Comparative Genomics; Large scale genome sequencing strategies; Human genome project; Arabidopsis genome project; Rice genome project; Comparative genomics tools; Introduction to proteomics; 2D gel electrophoresis; chromatography & sequencing by Edman degradation & mass spectrometry; Endopeptidases; Nanotechnology and its applications in crop improvement.

**UNIT-IV:** Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer; Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane *etc* and commercial releases; Biotechnology applications in male sterility/ hybrid breeding, molecular farming; Application of Tissue culture in molecular breeding; MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights; Introduction to bioinformatics: bioinformatics tools, biological data bases (primary & secondary), implications in crop improvement.

**PRACTICAL**

- Requirements for plant tissue culture laboratory;
- Techniques in plant tissue culture;
- Media components and media preparation;
- Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations;
- Inoculation of explants, callus induction and plant regeneration, Standardizing the protocols for regeneration;
- Hardening of regenerated plants; Establishing a greenhouse and hardening procedures;
- Visit to commercial micropropagation unit;
- Transformation using *Agrobacterium* strains,
- GUS assay in transformed cells/ tissues;
- DNA isolation, DNA purity and quantification tests,
- Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship;
- Construction of genetic linkage maps using computer software;
- NCBI Genomic Resources, GBFF, Swiss Prot, Blast n / Blast p, Gene Prediction Tool;
- Expasy Resources, PUBMED & PMC, OMIM & OMIA, ORF finder;
- Comparative Genomic Resources: - Map Viewer (UCSC Browser & Ensembl);
- Primer designing- Primer 3/ Primer BLAST.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**


1. Azuaje, F. & Dopazo, J. (2005). Data Analysis and Visualization in Genomics and Proteomics. John Wiley & Sons.
2. Brown, T. A. (1991). Essential Molecular Biology: a practical Approach. Oxford University press, 2002, 2nd edition.
3. Chawala, H. S. (2000). Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd.
4. Chopra, V. L. & Nasim, A. (1990). Genetic Engineering and Biotechnology: Concepts, Methods and Applications. Oxford & IBH.
5. Gupta, P. K. (1997). Elements of Biotechnology. Rastogi Publ.
6. Hackett, P. B., Fuchs, J. A. & Messing, J. W. (1988). An Introduction to Recombinant DNA Technology- Basic Experiments in Gene Manipulation. 2nd Ed. Benjamin Publ. Co. Jollès P & Jornvall.
7. Lewin, B. (2017). Genes XII. Jones & Bartlett learning, 2017

8. Robert, N. T. and Dennis, J. G. (2010). Plant Tissue Culture, Development, and Biotechnology. CRC Press.
9. Sambrook, J. & Russel, D. (2001). Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.
10. Singh, B. D. (2005). Biotechnology, Expanding Horizons. Kalyani Publ.
11. Watson, J. (2006). Recombinant DNA. Cold Spring Harbor laboratory press.

| GPB 532 | HYBRID BREEDING | 3 (2+1) |
|---|---|---|

**WHY THIS COURSE?**

This course will expose the students with the basic concepts of hybrid varieties and various techniques for development of hybrids in crop plants. This will also give an overview of various kinds of male sterility and their utilization in hybrid seed production of important field crops.

**AIM OF THE COURSE**

To provide knowledge of understanding about mechanisms of heterosis and its exploitation for yield improvement through conventional and biotechnological approaches.

**COURSE OUTCOME**

After completing this course, the student will be able to know about importance of heterosis, various conventional and biotechnological approaches for the development of hybrids. This will also enable student to know about the use of male sterility in hybrid seed production of important field crops.

**THEORY**

**UNIT-I:** Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Evolutionary aspects; Genetic consequences of selfing, sibbing and crossing in self and cross-pollinated and asexually propagated crops; Pre-Mendelian and Post-Mendelian ideas, Evolutionary concepts of heterosis; Genetic theories of heterosis– Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis.

**UNIT-II:** Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in $F_2$ and segregating populations, importance of inbreeding in exploitation of heterosis, case studies; Relationship between genetic distance and expression of heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/ genetic stocks and inbreeds, their improvement for increasing heterosis.

**UNIT-III:** Male sterility and use in heterosis breeding; Male sterile line creation and diversification in self-pollinated, cross-pollinated and asexually propagated crops; Creation of male sterility through genetic engineering and its exploitation in heterosis; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids.

**UNIT-IV:** Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreeds and parental lines, A, B and R lines, functional male sterility; Commercial exploitation of heterosis, maintenance breeding of parental lines in hybrids; Fixation of heterosis in self, cross and often cross pollinated crops, asexually/ clonally propagated crops, problems and prospects; Apomixis in fixing heterosis, concept of single line hybrid; Organellar heterosis and complementation.

**UNIT-V:** Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum and rapeseed mustard, sunflower, safflower and castor oilseed crops and pigeonpea.

**PRACTICAL**

- Characterization of male sterile lines using morphological descriptors;
- Restorer line identification and diversification of male sterile sources;
- Male sterile line creation in crop plants, problems in creation of CGMS system, ways of overcoming them;
- Diversification and restoration;
- Success stories of hybrid breeding in maize, rice, pearl millet, sorghum and pigeon pea;

- Understanding the difficulties in breeding apomicts;
- Estimation of heterotic parameters in self, cross and asexually propagated crops;
- Estimation from the various models for heterosis parameters;
- Hybrid seed production in field crops– an account on the released hybrids, their potential, problems and ways of overcoming it;
- Hybrid breeding at National and International level, opportunities ahead.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Agarwal, R. L. (1998). Fundamental of Plant Breeding & hybrid Seed Production. Science Publisher Landon.
2. Akin, E. (1979). The Geometry of Population Genetics. Springer-Verlag.
3. Ben, H. L. (1998). Statistical Genomics – Linkage, Mapping and QTL Analysis. CRC Press.
4. Chal, G. S. and Gossal, S. S. (2002). Principles and Procedures of Plant Breeding, Biotechnology and Convetional Approaches. Narosa Publishing, New Delhi
5. De, J. G. (1988). Population Genetics and Evolution. Springer-Verlag.
6. Hartl, D. L. (2000). A Primer of Population Genetics. 3rd Ed. Sinauer Assoc.
7. Mettler, L. E. & Gregg, T. G. (1969). Population Genetics and Evolution. Prentice-Hall.
8. Montgomery, D. C. (2001). Design and Analysis of Experiments. 5th Ed., John Wiley & Sons.
9. Mukherjee, B. K. (1995). The Heterosis Phenomenon. Kalyani Publ.
10. Proceedings of Genetics and Exploitation of Heterosis in Crops – An International Symposium CIMMYT, 1998.
11. Richards, A. J. (1986). Plant Breeding Systems. George Allen & Unwin.
12. Singh, B. D. (2006). Plant Breeding. Kalyani Publ.
13. Srivastava, S. & Tyagi, R. (1997). Selected Problems in Genetics. Vols. **I**, **II**. Anmol Publ.
14. Virmani, S. S. I. (994). Heterosis and Hybrid Rice Breeding. Monographsof "Theoretical and Applied Genetics", Springer-Verlag.

## GPB 533 CROP BREEDING-I (*KHARIF* CROPS) 3 (2+1)

**WHY THIS COURSE?**

Botanical features, reproductive systems, genetics involved and important breeding techniques are essential to undertake any crop improvement programme. This course is designed for important/ major *Kharif* field crops.

**AIM OF THE COURSE**

To provide insight into recent advances in improvement of kharif cereals, legumes, oilseeds, fibre, sugarcane and vegetative propagated crops using conventional and modern biotechnological approaches.

**COURSE OUTCOME**

After completing this course, the student will be able to know about important botanical status and reproductive structures of crops and genetics of important kharif field crops.

**THEORY**

**UNIT-I**

**Rice:** Origin, evolution, mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement; Aerobic rice, its implications and drought resistance breeding.

**Maize:** Origin, evolution, mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement; QPM and Bt maize- strategies and implications.

**Sorghum:** Evolution and distribution of species and forms, wild relatives and germplasm, Cytogenetics and genome relationship, Breeding objectives, yield, quality characters, biotic and abiotic stress resistance *etc*.

**Pearl millet:** Evolution and distribution of species and forms- wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters.

**Small millets:** Evolution and distribution of species and forms- wild relatives and germplasm; Cytogenetics and genome relationship - breeding objectives yield, quality characters, biotic and abiotic stress resistance *etc*.

**UNIT-II**

**Pigeon pea:** Evolution, mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement; Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at National and International institutes.

**Groundnut:** Origin, evolution mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

**Other pulses: Urdbean, mungbean, cowpea:** Origin, evolution, mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

**UNIT-III**

**Soybean:** Origin, evolution, mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

**Castor and Sesame:** Origin, evolution mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement; Hybrid breeding in castor–opportunities, constraints and achievements.

**UNIT-IV**

**Cotton:** Origin, evolution, mode of reproduction, chromosome number; Genetics- cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Development and maintenance of male sterile lines, Hybrid development and seed production, Scenario of Bt cottons, evaluation procedures for Bt cotton.

**UNIT-V**

**Sugarcane:** Evolution and distribution of species and forms, wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc*.

**Forage crops:** Evolution and distribution of species and forms- Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance *etc.*,

**Seed spices:** Origin, evolution, mode of reproduction, chromosome number; Genetics-cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc.*,; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement; Achievements of important spice crops.

**PRACTICAL**

- Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea, soybean, sesame, cotton;
- Study of range of variation for yield and yield components;
- Study of segregating populations in cereal, pulses and oilseed crops;
- Learning on the crosses between different species; attempting crosses between black gram and green gram;
- Evaluating the germplasm of cotton for yield, quality and resistance parameters, learning the procedures on development of Bt cotton;
- Visit to Cotton Technology Laboratory and Spinning Mills;
- Learning on the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval;
- Practical learning on the cultivation of fodder crop species on sewage water, analyzing them for yield components and palatability;
- Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes;
- Visit to animal feed producing factories;
- Learning the practice of value addition; Visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations

**SUGGESTED READINGS**


1. Agarwal, R. L. (1996). Identifying Characteristics of Crop Varieties. Oxford & IBH.
2. Bahl, P. N. & Salimath, P. M. (1996). Genetics, Cytogenetics and Breeding of Crop Plants. Vol.I. Pulses and Oilseeds. Oxford & IBH.
3. Chandraratna, M. F. (1964). Genetics and Breeding of Rice. Longmans.
4. Chopra, V. L. & Prakash, S. (2002). Evolution and Adaptation of Cereal Crops. Oxford & IBH.
5. Gill, K. S. 1991. Pearl Millet and its Improvement. ICAR.
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7. IRRI. 1986. Rice Genetics. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
8. IRRI. 1991. Rice Genetics II. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
9. IRRI. 1996. Rice Genetics III. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
10. IRRI. 2000. Rice Genetics IV. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
11. Jennings, P. R., Coffman, W. R. & Kauffman, H. E. (1979). Rice Improvement. IRRI, Los Banos, Manila, Philippines.
12. Kannaiyan, S., Uthamasamy, S., Theodore, R. K. & Palaniswamy, S. (2002). New Dimensions and Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU, Coimbatore.
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14. Nanda, J. S. (1997). Manual on Rice Breeding. Kalyani Publishers.
15. Parthasarathy, V. A. (2017). Spices and Plantation Crops Vol.**1** (Part A) Breeding of Horticultural Crops Vol.**1** (Part-B), Today and Tomorrow Printers and Publishers.

16. Poehlman, J. M. (1987). Breeding of Field Crops. AVI Publishing Co. Inc. East Post Connecticut, USA.
17. Ram, H. H. & Singh, H. G. (1993). Crop Breeding and Genetics. Kalyani Publishers.
18. Sharma, A. K. (2005). Breeding Technology of Crop Plant. Yesh Publishing House, Bikaner.
19. Singh, H. G., Mishra, S. N., Singh, T. B., Ram, H. H. & Singh, D. P. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.
20. Slafer, G. A. (Ed.). 1994. Genetic Improvement of Field Crops. Marcel Dekker.
21. Walden, D. B. (1978). Maize Breeding and Genetics. John Wiley & Sons.

## GPB 534 VARIETAL DEVELOPMENT AND MAINTENANCE BREEDING 3 (2+1)

**WHY THIS COURSE?**

It is an indispensable course which apprise the students about various practices and procedures in the development of a variety and steps to maintain the purity of varieties/ hybrids. Further, it provides basics of nucleus and breeder seed production techniques.

**AIM OF THE COURSE**

The purpose of this course is to make students well acquainted with the techniques and procedures of varietal development. Student will be associated with development of variety so the course aims is to provide knowledge on DUS testing, protocols of various breeding techniques, procedures of release of variety, maintenance of the variety and production of nucleus and breeder seed of variety/ hybrids.

**COURSE OUTCOME**

Pass out student will have complete knowledge on the various procedures linked with the development and release of variety. This course will also enable student how to maintain and multiply variety for large scale distribution. It will also make student acquainted with the seed laws and acts related to plant variety protection.

**THEORY**

**UNIT-I:** Variety Development systems and Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, landraces, hybrid, and population; Variety testing, release and notification systems and norms in India and abroad.

**UNIT-II:** DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties- safeguards during seed production.

**UNIT-III:** Maintenance of varieties in self and cross pollinated crops, isolation distance; Principles of seed production; Methods of nucleus and breeder seed production; Generation system of seed multiplication - nucleus, breeders, foundation, certified.

**UNIT-IV:** Quality seed production technology of self and cross-pollinated crop varieties viz. cereals & millets (wheat, barley, paddy, pearl millet, sorghum, maize and minor millet *etc.*); Pulses (mungbean, black gram, cowpea, pigeonpea, chickpea, fieldpea, lentil, mothbean and clusterbean); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton/jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).

**UNIT-V:** Seed certification procedures; Seed laws and acts, plant variety protection regulations in India and international systems.

**PRACTICAL**

- Identification of suitable areas/locations for seed production;
- Ear-to-row method and nucleus seed production;
- Main characteristics of released and notified varieties, hybrids and parental lines, PGMS and TGMS;
- Identification of important weeds/ objectionable weeds;
- Determination of isolation distance and planting ratios in different crops;
- Seed production techniques of varieties in different crops;
- Hybrid seed production technology of important crops;

- DUS testing and descriptors in major crops;
- Variety release proposal formats in different crops

**TEACHING METHODS**

- Power point presentation,
- Chalk and Board
- Smart board
- Lectures,
- Assignments, quiz,
- Group tasks, student's presentations

**SUGGESTED READINGS**

1. Agarwal, R. L. (1997). Seed Technology. 2nd Ed. Oxford & IBH.
2. Kelly, A. F. (1988). Seed Production of Agricultural Crops. Longman.
3. McDonald, M. B Jr & Copeland, L. O. (1997). Seed Production: Principles and Practices. Chapman & Hall.
4. Poehlman, J. M. & Borthakur D (1969). Breeding Asian Field Crops. Oxford & IBH.
5. Singh, B. D. (2005). Plant Breeding: Principles and Methods. Kalyani Publisers.
6. Thompson, J. R. (1979). An Introduction to Seed Technology. Leonard Hill.

## GPB 535 SEED PRODUCTION AND CERTIFICATION 2 (1+1)

**WHY THIS COURSE?**

Seed is the essence of life. Its improvement, production and maintenance is an essential feature of any variety. Seed chain concept is highly relevant in commercial promotion of new varieties whereas process of certification is mandatory for quality assurance of seed.

**AIM OF THE COURSE**

To impart knowledge on principles of seed production and certification. This will help the students to understand seed production practices and seed certification procedures in different crops.

**COURSE OUTCOME**

After completing this course the student will be able to know about seed production of different crop varieties and hybrids, their processing, marketing and seed laws.

**THEORY**

**UNIT-I:** Importance of seed as basic input in agriculture; Seed quality concept and importance; Generation system of seed multiplication, Varietal replacement rate, Seed multiplication ratio, Seed replacement rate, Seed renewal period and seed demand and supply; Various factors influencing seed production, Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration.

**UNIT-II:** Nucleus seed production and its maintenance, Maintenance of parental lines of hybrids, Production of breeder, foundation and certified seed and their quality maintenance; Principles of seed production in self- and cross-pollinated crops; Hybrid seed production- system and techniques involved in Seed village concept; Organic seed production & certification.

**UNIT-III:** Principles of seed production in field crops; Floral structure, pollination mechanism and seed production techniques in self- & cross-pollinated cereals and millets.

**UNIT-IV:** Floral structure, pollination mechanism and methods and techniques of seed production in major pulses & oilseed crops; Varietal and hybrid seed production techniques in Pigeon pea, Mustard, Castor & Sunflower.

**UNIT-V:** Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibres. Hybrid-seed production techniques in major vegetatively propagated crops.

**UNIT-VI:** Seed certification- history, concept, objectives; Central seed certification board Seed certification agency/ organization and staff requirement; Legal status; Phases of seed certification, formulation, revision and publication of seed certification standards; Minimum Seed Certification Standards (MSCS) for different crops- General and specific crop standards, Field and seed standards; Planning and management of seed certification programs; Eligibility of a variety for certification, area assessment, cropping history of the seed field.

**PRACTICAL**

- Planting design for variety- hybrid seed production techniques, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony,
- Identification of rogues and pollen shedders, supplementary pollination, detasseling, hand emasculation and pollination;
- Pollen collection and storage methods, pollen viability and stigma receptivity;
- Pre-harvest sanitation, maturity symptoms, harvesting techniques;
- Visits to seed production plots - visit to seed industries;
- Planning for seed production: cost benefit ratio, seed multiplication ratio & seed replacement rate;
- General procedure of seed certification, identification of weed and other crop seeds as per specific crops, field inspection at different stages of a crop and observations recorded on contaminants and reporting of results, inspection and sampling, harvesting/ threshing, processing and after processing for seed law enforcement;
- Specifications for tags and labels to be used for certification purpose.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures,
- Assignments/ quiz
- Group tasks, student's presentations

**SUGGESTED READINGS**

1. Agrawal, P.K. and Dadlani, M. (1987). Techniques in Seed Science and Technology, South Asian Publishers, Delhi.
2. Agrawal, R. L. (1997). Seed Technology, Oxford & IBH Publishing.
3. Anon. (1965). Field Inspection Manual and Minimum Seed Certification Standards, NSC Publication, New Delhi.
4. Anon. (1999). Manual of Seed Certification procedures. Directorate of Seed Certification, Coimbatore, Tamil Nadu.
5. Joshi, A. K. and Singh, B. D. (2004). Seed Science and Technology, Kalyani Publ.
6. Kelly, A. F. (1988). Seed Production of Agricultural Crops. John Wiley, New York.
7. McDonald, M. B. & Copeland, L. O. (1997). Seed Science and Technology, Scientific Publisher.
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9. Singhal, N. C. (2003). Hybrid Seed Production in Field Crops, Kalyani Publications, New Delhi
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11. www.gov.mb.ca, www.agricoop.nic.in, www.agri.nic.in,
12. www.fao.org,
13. www.seednet.gov.in

## GPB 536 GERMPLASM CHARACTERIZATION AND EVALUATION 2 (1+1)

**WHY THIS COURSE?**

Students need to learn about morphological and quality agronomic traits of accessions as well as their reaction to biotic and abiotic stresses. This will increase the importance of the germplasm.

**AIM OF THE COURSE**

Students will gain knowledge on germplasm characterisation, evaluation and documentation of information. Recording of morphological and agronomic traits, including quality, as well as those for resilience to biotic and abiotic stresses that will promote utilisation. Exposure to development of web based tools for systematic description for efficient use of germplasm.

**COURSE OUTCOME**

To educate students about science of managing genetic resources including principles involved in maintaining genetic integrity during regeneration, germplasm characterization and evaluation.

**THEORY**

**UNIT-I:** Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; Germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits; Measuring diversity using agro-morphological data, statistical procedures to measure population genetic variation, markers and their use in PGR, evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

**UNIT-II:** Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces, evaluation and maintenance of wild relatives of crop plants. Genetic enhancement, Use of CWRs genetic resources for crop improvement.

**UNIT-III:** High throughput phenotyping systems - imaging & image processing concepts for automated germplasm characterization (phenotyping) – evaluation for nutritional traits, resistance traits Biochemical and molecular markers for characterization.

**PRACTICAL**

- Field layout and experimental designs;
- recording field data on germplasm evaluation in different agri-horticultural crops,
- post harvest handling;
- evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm;
- data processing; documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing, biochemical analyses of samples.

**TEACHING METHODS**

- Lectures
- Power point presentations
- Assignments/ quiz
- Group tasks, student's presentations

**SUGGESTED READINGS**

1. Tripathi, K., Bhardwaj, R., Bhalla, S., Kaur, V., Bansal, R., Yadav, R., Gangopadhyay, K. K., Kumar, A. and Chaudhury, R. (2018). Plant Genetic Resources Evaluation: Principles and Procedures, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi.
2. Brown, A. H. D., Clegg, M. T., Kahler, A. L., Weir, B. S. (eds.) 1990. Plant Population Genetics, Breeding and Genetic Resources. Sinauer Associates, USA.
3. Frankel, R. and Galun, E. (1977). Pollination Mechanisms, Reproduction and Plant Breeding. Monographs on Theoretical and Applied Genetics, Springer-Verlag, Berlin, Heidelberg.
4. Hayward, M. D., Bosemak, N. O. and Romagosa, I. (1993). Plant Breeding: Principles & Practices, Chapman & Hall.
5. Holden, J. H. N. and Williams, J. T. (1984). Crop genetic resources: conservation and evaluation, IBPGR.
6. Stoskopf, N. C. (1993). Plant Breeding: Theory & Practice, Westview Press.
7. Puzone, L. and Th. Hazekamp (1996). Characterization and Documentation of Genetic Resources Utilizing Multimedia Database. NBPGR, New Delhi.
8. Rana, R. S., Sapra, R. L., Agrawal, R. C. and Gambhir, R. (1991). Plant Genetic Resources, Documentation and Information Management. NBPGR, New Delhi.
9. Sundeep Kumar, *et al.* (2016). Evaluation of 19,460 wheat accessions conserved in the Indian national gene bank to identify new sources of resistance to rust and spot blotch diseases. PloS One Vol. II, pages 0167702.

## GPB 537 GENETIC ENHANCEMENT FOR PGR UTILIZATION 2 (1+1)

**WHY THIS COURSE?**

Pre-breeding is a vital step in the link between plant genetic resources conservation and its use; Hence, this course is designed to inculcate theoretical and practical know how to understand and use classical and advanced plant breeding methods for planning and execution of pre-breeding programmes so that the PGR is put into effective use for food and agriculture.

**AIM OF THE COURSE**

To teach theoretical and practical know how on CWRs reproductive behaviour, acclimatization and adaptation for utilization in pre-breeding programmes using advanced tools.

**COURSE OUTCOME**

Students would be conversant with handling of unadapted germplasm, screening methods for special traits-biotic and abiotic resistance, nutritional traits, characterization of CWR, breeding, *etc*.

**THEORY**

**UNIT-I:** Concepts of gene pools; Introduction, potential of pre-breeding. Role of crop wild relatives, semi exotics, creating and managing variation, basic concepts to set up a successful prebreeding programme.

**UNIT-II:** Understanding crop adaptation, handling and maintenance of CWRs, synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments, role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm, identifying desirable traits in natural populations, screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits, genetic analysis to understand the inheritance of novel traits.

**UNIT-III:** Parental selection for pre-breeding, search for superior genotypes, breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization, Incongruity and its management, modern tools for incongruity management, cytogenetical approaches for gene transfer such as alien addition and substitution, segregating populations and their management in wide crosses, purging the undesirable traits, testing and improving the adaptability of wide cross derivatives, cytological studies, florescence microscopy, embryo rescue methods, pollen physiology and storage, pollen storage methods to facilitate wide hybridization, pre & post-zygotic barriers.

**PRACTICAL**

- Characterization of CWRs by visiting the fields;
- Screening methods for special traits-biotic and abiotic resistance;
- Screening for nutritional traits;
- Crossability studies in CWRs of cereals, legumes, oilseeds, vegetables;
- Assessment of pre and post-zygotic barriers in wide hybridization crosses;
- Pollen storage studies;
- Special requirements for growing CWRs, inducing flowering by manipulating day length, temperature, chemical spraying, *etc*.

**TEACHING METHODS**

- Lectures,
- Power point presentations,
- assignments, quiz,
- Group tasks, student's presentations

**SUGGESTED READINGS**

1. Sharma, S., Upadhyaya, H. D., Varshney, R. K. (2013). Pre-breeding for diversification of primary gene pool and genetic enhancement of grain legumes. Front. Plant Sci. **4**:309.
2. Bisht, *et al.* 2004. Broadening the genetic base of sesame (*Sesamum indicum* L.) through genetic enhancement. Plant Genetic Resources **2(3):** 143-151.
3. Duvick, D. N. (1990). Genetic enhancement and Plant breeding. p. 90-96. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland.

4. Ram, J. S. (2010). Plant Cytogenetics. CRC Press.
5. Ramanatha Rao, V., Brown, A. H. D, Jackson, M. (2001). Managing Plant Genetic Diversity. CABI Publication.
6. Andey Pereira (2006). Plant Reverse Genetics, Methods and, Humana Press.
7. Yunbi Xu (2010). Molecular plant breeding. CABI publishers
8. Dale, J. W. and von Schantz, M. (2007). From genes to genomes- Concepts and Applications of DNA technology. John Wiley & Sons Ltd., Chichester, England.
9. Goodman, R. M. (2004). Encyclopedia of plant and crop science. Marcel Dekker Inc., Switzerland.
10. Kimber, G. and Feldman, M. (1987). Wild Wheat: An introduction. Special report 353, College of Agriculture, University of Missouri-Columbia.
11. Lynch, M. and Walsh, B. (1998). Genetics and analysis of quantitative traits. Sinauer Associates Inc.
12. Murphy, D. (2007). Plant breeding and Biotechnology: Societal Context and the Future of Agriculture. Cambridge University Press, Cambridge, UK.
13. *e*-Resources-
    https://www.integratedbreedPlaning.net/pre-breeding-effective-use-plant-geneticresources
    http://www.croptrust.org,
    http://www.bioversityinternational.org/training/training_materials/pre_breeding.htm
    http://www.grdc.com.au/director/research/prebreeding.

# COURSE CONTENTS: Ph.D. GENETICS AND PLANT BREEDING

## GPB 611 ADVANCES IN PLANT BREEDING SYSTEMS 3 (3+0)

**WHY THIS COURSE?**

This course is an advancement of principles, various plant breeding methodologies and procedures in the development of a complex population; MAS for selection of qualitative and quantitative traits, Gene pyramiding, marker-based utilization of exotic Germplasm and introgression libraries.

**AIM OF THE COURSE**

To impart theoretical knowledge about advances in plant breeding.

**COURSE OUTCOME**

After completion of this course the student will be able to know various plant breeding methodologies, principles and procedures for the formation of a complex population; MAS for selection of qualitative and quantitative traits, Gene pyramiding, marker based utilization of exotic Germplasm and Breeding for climate change.

**THEORY**

**UNIT-I:** Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed; Pollen pistil interaction: biochemical and molecular basis, environmental factors governing anthesis and bottlenecks for gene transfer.

**UNIT-II:** Plant Breeding methodologies- Classic versus modern; Over view of Pre and Post Mendelian breeding methods in self and cross pollinated crops; Molecular and transgenic breeding approaches; doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed breeding, participatory plant breeding, breeding for organic situations.

**UNIT-III:** Principles and procedures in the formation of a complex population; Genetic basis of population improvement in crop plants; Recurrent selection methods in self and cross pollinated crops and their modifications; Convergent selection, divergent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selection in clonally propagated crops – Assumptions and realities.

**UNIT-IV:** Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment, application of MAS for selection of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotic germplasm, introgression libraries.

**UNIT-V:** Genetic resources: primary, secondary, tertiary and alien trans gene pool; Molecular and biochemical basis of self-incompatibility and male sterility, nucleocytoplasmic interactions with special reference to male sterility– genetic, biochemical and molecular bases.

**UNIT-VI:** Genetic engineering technologies to create male sterility, prospects and problems, use of self-incompatibility and sterility in plant breeding– case studies; Fertility restoration in male sterile lines and restorer diversification programs; Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies; Case studies- generating new cyto-nuclear interaction system for diversification of male sterile; Stability of male sterile lines– environmental influence on sterility, Environmentally Induced Genic Male Sterility (EGMS)– Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding; Temperature sensitive genetic male sterility and its use heterosis breeding; Apomixis and its use in heterosis breeding; Incongruity: Factors influencing incongruity Methods to overcome incongruity mechanisms.

**UNIT-VII:** Breeding for climate change -Improving root systems, abiotic stress tolerance, water use efficiency, flooding and sub-mergence tolerance; Biotic stress tolerance; Nutrient use efficiency, nitrogen fixation and assimilation, greenhouse gases and carbon sequestration; Breeding for bio-fortification.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board

- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**


1. Agarwal, R. L. (1996). Fundamentals of Plant Breeding and Hybrid Seed Production. Oxford & IBH.
2. Allard, R. W. (1966). Principles of Plant Breeding. John Wiley & Sons.
3. Briggs, F. N. and Knowles, P. F. (1967). Introduction to Plant Breeding. Reinhold.
4. Fehr, W. R. (1987). Principles of Cultivar Development: Theory and Technique. Vol.**I**. Macmillan.
5. Hayes, H. K., Immer, F. R. & Smith, D. C. (1955). Methods of Plant Breeding. McGraw-Hill.
6. Kang, M. S. and Priyadarshan, P. M. (2007). Breeding Major Food Staples. Blackwell Publishing.
7. Kole, C. (2013). Genomics and Breeding for Climate-Resilient Crops. Springer. Vol.**2** Target Traits.
8. Mandal, A. K., Ganguli, P. K. & Banerji, S. P. (1995). Advances in Plant Breeding. Vol. **I**, **II**. CBS.
9. Richards, A. J. (1986). Plant Breeding Systems. George Allen & Unwin.
10. Sharma, J. R. (1994). Principles and Practice of Plant Breeding. Tata McGraw-Hill.
11. Simmonds, N. W. (1979). Principles of Crop Improvement. Longman.
12. Singh, B. D. (1997). Plant Breeding: Principles and Methods. 5$^{th}$ Ed., Kalyani Publ.
13. Singh, P. (1996). Essentials of Plant Breeding. Kalyani Publ.
14. Welsh, J. R. (1981). Fundamentals of Plant Genetic and Breeding. John Wiley & Sons.


## GPB 612 GENOMICS IN PLANT BREEDING 3 (3+0)

**WHY THIS COURSE?**

The knowledge of recent trends in plant genomics, genome sequencing, molecular maps, and concepts of high-throughput proteomics, metabolomics and phenomics is essential in rapid crop improvement programmes.

**AIM OF THE COURSE**

To impart practical skills in advanced molecular techniques in genome mapping structural/ functional genomics.

**COURSE OUTCOME**

After the completion of this course, the student will have expertise on about different techniques for genome sequencing, molecular maps, and concepts of high-throughput proteomics, metabolomics and phenomics in crop improvement.

**THEORY**

**UNIT-I:** Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes; Concept of genome size and complexity: C-value paradox, repetitive and unique DNA.

**UNIT-II:** Genome sequencing: Principles and techniques of conventional approaches and next generation sequencing including sequencing-by-synthesis/ ligation and single molecule real time (SMRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing including shot gun and clone-by-clone method.

**UNIT-III**

Molecular maps: Use of molecular markers/ SNPs for development of genetic and physical maps; Linkage and LD-based gene mapping approaches including gene/ QTL mapping, genome wide association studies (GWAS) and association analysis; Integration of genetic and physical map for map-based cloning of economically important genes. Concept of allele mining; Diversity array technology: concepts and applications.

**UNIT-IV:** Functional genomics: concept of reverse and forward genetics; Use of activation tagging, transposon tagging, insertional mutagenesis, TILLING and ecoTILLING for crop improvement;

Genome-wide and gene-specific transcriptomics approaches: serial analysis of gene expression, massively parallel signature sequencing, next generation sequencing, microarray, northern hybridization, RT-PCR, qRT-PCR and molecular beacon.

**UNIT-V:** Development and management of database; Applications of bioinformatics tools/ software in genomics for crop improvement. Basic concepts of high-throughput proteomics, metabolomics and phenomics.

**UNIT-VI:** Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENS and ZFNs for crop improvement. Cisgenesis and Intragenesis tools as twin sisters for Crop Improvement; Genomics-based plant breeding: Genome-Wide Genetic Diversity Studies, Identification of molecular markers linked to single Genes and QTL, Marker Assisted Selection: Marker Assisted Backcross Selection, Association mapping, Breeding by Design, Genome selection.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Alonso, J. M. and Stepanova, A. N. (2015). Plant Functional Genomics: Methods and Protocols. Springer.
2. Chopra, V. L., Sharma, R. P., Bhat, S. R. and Prasanna, B. M. (2007). Search for New Genes. Academic Foundation, New Delhi
3. Hackett, P. B., Fuchs, J. A. & Messing, J. W. 1988. An Introduction to Recombinant DNA Technology - Basic Experiments in Gene and Manipulation. 2nd Ed. Benjamin Pub. Co.
4. Primose, S. B. and Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. 7th Ed. Wiley-Blackwell Publishing.
5. Sambrook, J. & Russel, D. (2001). Molecular Cloning -a Laboratory Manual. 3rd Ed. Cold Spring Harbor Laboratory Press.
6. Singh, B. D. (2005). Biotechnology: Expanding Horizons. Kalyani Publ.
7. Somers, D. J., Langridge, P. & Gustafson, J. P. (2009). Plant Genomics: Methods and Protocols. Springer http://gramene.org https://www.arabidopsis.org
8. https://wheat.pw.usda.gov http://ncbi.nlm.nih.gov http://www.maizegenetics.net

## GPB 621 ADVANCES IN BIOMETRICAL GENETICS 3 (2+1)

**WHY THIS COURSE?**

This course is essential to understand various qualitative, quantitative systems/ techniques related to genetic improvement of crops, G x E Interaction, Construction of saturated linkage maps and Marker Assisted Selection (MAS).

**AIM OF THE COURSE**

To impart theoretical knowledge and computation methods for non-allelic interactions, mating designs and component analysis and their significance in plant breeding.

**COURSE OUTCOME**

After the completion of this course student will be able to understand various qualitative and quantitative techniques, G x E Interaction, Construction of saturated linkage maps and Marker Assisted Selection, Use of advanced software packages for biometrical analysis, interpretation of analysed data.

**THEORY**

**UNIT-I:** Continuous variation- evolutionary studies; Genetic principles of continuous variation, Qualitative and quantitative techniques, differences, population types, approaches; various types of metrices, $F_2$, $F_\alpha$ and mixed; Selection of parents Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes.

**UNIT-II:** Components of mean- additive effect, breeding value, coefficient of gene dispersion, dominance; Simple scaling test, expectation of mean of character in various types of families in coupling and dispersed phase; Epistasis- Specification, weighted and unweighted joint scaling test; Effect of linkage to generation mean, specification of mean to G x E interaction.

**UNIT-III:** Component of variances - advantages, variances of different generations, balance sheet of variance; estimation of parameters - weighted and unweighted, least square analysis; random mating population; experimental population-BIPs, NCD-I, II, III, Triple test cross for random mating population and inbreds; Estimates of linkage and non-allelic interactions; Combining ability analysis, Hayman's Approach.

**UNIT-IV:** G x E Interaction, stability and adaptability; Advanced models in stability analysis– Pattern analysis- Additive Main effect and Multiplicative Interaction (AMMI) analysis and other related models; Merits and limitation of different stability analysis methods; Analysis and selection of genotypes; Methods and steps to select the best model- Biplots and mapping genotypes.

**UNIT-V:** Construction of saturated linkage maps, concept of framework map development; QTLs different types of markers and mapping populations, linkage maps, mapping-strategies for QTL mapping - desired populations, statistical methods; MAGIC populations, Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding, selection based on markers, simultaneous selection based on marker and phenotype, Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods; Use of advanced software packages for biometrical analysis, interpretation of analysed data.

**PRACTICAL**

- Generation mean analysis: ABC scaling test and Joint scaling test - Analysis and interpretation;
- Estimation of variance of different filial generations and interpretations;
- Diallel analysis: Numerical, graphical and combining ability analysis;
- Triallel analysis;
- NC Designs: Triple test cross analysis,
- Stability analysis: Eberhart and Russel model;
- AMMI model - Principal Component Analysis model- Additive and multiplicative model- Shifted multiplicative model, Analysis and selection of genotypes- Methods and steps to select the best model- Selection systems;
- Biplots and mapping genotypes;
- Construction of linkage maps and QTL mapping- Strategies for QTL mapping, statistical methods in QTL mapping;
- Phenotype and Marker linkage studies;
- Use of advanced software in biometrical analysis.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Bos, I. & Caligari, P. (1995). Selection Methods in Plant Breeding. Chapman & Hall.
2. Dabholkar, A. R. (1993). Elements of Biometrical Genetics. Concept Publishing Co. New Delhi.
3. Falconer, D. S. & Mackay, J. (1996). Introduction to Quantitative Genetics (4Ed.).ELBS/ Longman, London.
4. Mather, K. & Jinks, J. L. (1985). Biometrical Genetics ($3^{rd}$ Ed.). Chapman and Hall, London.
5. Nandarajan, N. and Gunasekaran, M. (2008). Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani Publ.
6. Roy, D. (2000). Plant Breeding: Analysis and Exploitation of Variation. Narosa Publishing House, New Delhi.

7. Singh, P. & Narayanan, S. S. (1993). Biometrical Techniques in Plant Breeding. Kalyani Publ.
8. Singh, R. K. & Choudhary, B. D. (1987). Biometrical Methods in Quantitative Genetics Analysis. Kalyani Publ.
9. Weir, D. S. (1990). Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.
10. Wricke, G. & Weber, W. E. (1986). Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.

## GPB 622 IPR AND REGULATORY MECHANISM (*e*-course) 1 (1+0)

**WHY THIS COURSE?**

Biodiversity conservation and its judicious utilization are important in sustainable plant breeding programs. Breeders' and farmers' rights are important in scenario of globalization of agriculture so knowledge of IPRs is essential for a plant breeder to protect his varieties.

**AIM OF THE COURSE**

The main objective of this course is to equip students and stakeholders with knowledge of Intellectual property rights (IPR), related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

**COURSE OUTCOME**

The students will have acquaintance of intellectual property rights, national and international laws on biodiversity and sustainable use of plant genetic resources through transfer and sharing. Can assist in follow up of various treatises and laws for research collaborations at international levels.

**THEORY**

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

**TEACHING METHODS**

- Power point presentation
- Smart board
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Erbisch, F. H. & Maredia, K. (1998). Intellectual Property Rights in Agricultural Biotechnology. CABI.
2. Ganguli, P. (2001). Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
3. Intellectual Property Rights: Key to New Wealth Generation (2001). NRDC & Aesthetic Technologies.
4. Ministry of Agriculture, Government of India (2004). State of Indian Farmer. Vol. **V**. Technology Generation and IPR Issues. Academic Foundation.

## GPB 623 BREEDING DESIGNER CROPS 2 (1+1)

**WHY THIS COURSE?**

This course enlightens about developing varieties for special traits, physiological efficiency and nutritional enhancement. It gives concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products.

**AIM OF THE COURSE**

Breeding crops for higher physiological efficiency and nutritional enhancement.

**COURSE OUTCOME**

Pass outs will have clear understanding of ideotypes of crops under varied agro-climatic situations and breed for physiological efficient genotype. Can develop varieties for special traits having high therapeutic and nutracetical value.

**THEORY**

**UNIT-I:** Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds- proteins, vaccines, gums, starch and fats.

**UNIT-II:** Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement; Breeding for special traits viz., oil, protein, vitamins, amino acids *etc.*; Ecospecific ideotypes, Ideotypes for high and low moisture conditions, low and high input conditions, conversion mechanism of $C_3$ to $C_4$ plants; Determination of genetics of above mentioned traits.

**UNIT-III:** Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of suboptimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.

**UNIT-IV:** Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories in vaccines, modified sugars, gums and starch through biopharming.

**UNIT-V:** Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management.

**PRACTICAL**

Demonstration of plant responses to stresses through recent techniques; Water use efficiency, transpiration efficiency, screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation, heat/drought/salt shock proteins.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Balint, A. (1984). Physiological Genetics of Agricultural Crops. AK Ademiaikiado.
2. Hay, R. K. (2006). Physiology of Crop Yield. 2nd Ed. Blackwell.
3. Pessarakli, M. (1995). Handbook of Plant and Crop Physiology. Marcel Dekker.
4. Taiz, L. & Zeiger, E. (2006). Plant Physiology. 4th Ed. Sinauer Associates.

## GPB 624 MOLECULAR CYTOGENETICS FOR CROP IMPROVEMENT 2 (2+0)

**WHY THIS COURSE?**

This course is needed to understand organization and structure of genome, karyotyping, Pre-breeding and applications of cytogenetically methods for crop improvement

**AIM OF THE COURSE**

This course focuses on applications of cytogenetic techniques for crop improvement.

**COURSE OUTCOME**

After the completion of this course the student will be able to understand Organization and structure of genome, karyotyping, Pre-breeding, polyploidy and applications of cytogenetic methods for crop improvement.

**THEORY**

**UNIT-I:** Organization and structure of genome, Genome size, Organization of organellar genomes, Nuclear DNA organization, Nuclear and Cytoplasmic genome interactions and signal transduction; Inheritance and expression of organellar DNA; Variation in DNA content -C value paradox; Sequence complexity– Introns and Exons, Repetitive sequences, Role of repetitive sequence.

**UNIT-II:** Karyotyping– Chromosome banding and chromosome painting; Tracking introgressions using FISH, GISH, localization and mapping of genes/ genomic segments.

**UNIT-III:** Pre-breeding and applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchange genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges -use in producing inbreds, transfer of genes-linked marker methods; Duplication -production and use; Inversions and location of genes; B/A chromosome translocations and gene location.

**UNIT-IV:** Trisomics- types, production, breeding behaviour and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomics methods of production, breeding behaviour and location of genes; Intervarietal substitutions -allelic and non-allelic interactions; Telocentric method of mapping.

**UNIT-V:** Cytogenomics: Concept, tools and techniques for crop improvement; Chromosome sorting: Isolation of specific chromosome for development of molecular maps and gene location.

**UNIT-VI:** Role of polyploidy in crop evolution and breeding. Auto and allopolyploids; Distant hybridization, barriers to interspecific and intergeneric hybridization; Behaviour of interspecific and intergeneric crosses.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Clark, M. S. & Wall, W. J. (1996). Chromosomes: The Complex Code. Chapman & Hall.
2. Conger, B. V. (1981). Cloning Agricultural Plants via *in vitro* Techniques. CRC Press.
3. Constabel, F. & Vasil, I. K. (Eds.). 1988. Cell Culture and Somatic Cell Genetics of Plants. Vol. V. Cell Culture and Phytochemicals in Plant Cell Cultures. Academic Press.
4. Gupta, P. K. (2006). Cytogenetics. Rastogi Publisher.
5. Lal, R. & Lal, S. (Eds.). 1990. Crop Improvement Utilizing Biotechnology. CRC Press.
6. Mantel, S. H. & Smith, H. (1983). Plant Biotechnology. Cambridge University Press.
7. Sen, S. K. & Giles, K. L. (Eds.). 1983. Plant Cell Culture in Crop Improvement. Plenum Press.
8. Yao-Shan, F. (2002). Molecular Cytogenetics: Protocols and Application. Human Press.

| GPB 625 | CROP EVOLUTION | 3 (3+0) |
|---|---|---|

**WHY THIS COURSE?**

This course imparts knowledge about the origin and evolution of species, centres of diversity, speciation, domestication and significance of polyploidy.

**AIM OF THE COURSE**

To impart knowledge on crop evolutionary aspects and role of mutations, hybridizations and polyploidy in crop evolution and improvement.

**COURSE OUTCOME**

After the completion of this course the student will have knowledge of Origin and evolution of species, Centres of diversity, Speciation, domestication and significance of micro-mutations and polyploidy in genetic improvement of crop plants.

**THEORY**

**UNIT-I:** Origin and evolution of species; Centres of diversity/ origin, diffused centres; Time and place of domestication; Patterns of evolution and domestication - examples and Case studies; Domestication and uniformity - Characteristics of early domestication and changes - Concept of gene pools and crop evolution; Selection and Genetic drift - Consequences.

**UNIT-II:** Speciation and domestication; The process of speciation, Reproductive isolation barriers; Genetic differentiation during speciation; Hybridization - speciation and extinction; Exploitation of natural variation: Early attempts to increase variation, Distant hybridization and introgression, Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques; Validation of transferred genes and their expression; Controlled introgressions.

**UNIT-III:** Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization - Transgenesis in crop evolution, Multifactorial genome, Intragenomic interaction, Intergenomic interaction, Genome introgression; Methods to study crop evolution - Contemporary Methods, Based on morphological features, Cytogenetic analysis, Allozyme variations and crop evolution, DNA markers, genome analysis and comparative genomics.

**UNIT-IV:** Evolutionary significance of polyploidy, evolution of crop plants through ploidy manipulations; Polyploids: methods, use of autopolyploids; haploidy and DH-method of production and use, allopolyploids; synthesis of new crops; Case studies – Cereals, Pulses, Oilseeds, vegetables, Fibre crops ,Plantation crops, Forage crops, Tuber crops, Medicinal Plants.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**


1. Hancock, J. F. (2004). Plant Evolution and the Origin of Crop Species. 2nd Ed. CABI.
2. Ladizinsky, G. (1999). Evolution and Domestication. Springer.
3. Miller, A. J. (2007). Crop Plants: Evolution. John Wiley & Sons.
4. Smartt, J. & Simmonds. N. W. (1995). Evolution of Crop Plants. Blackwell.


## GPB 626 PLANT GENETIC RESOURCES, CONSERVATION AND UTILIZATION 2(2+0)

**WHY THIS COURSE?**

This course is needed to make the student aware about the importance of Plant Genetic Resources, its Conservation and Utilization in crop improvement.

**AIM OF THE COURSE**

To impart knowledge on the methods of germplasm conservation and its utilization.

**COURSE OUTCOME**

After the completion of this course the student will be able to know about the various techniques of conservation of Plant Genetic Resources and its Utilization in crop improvement.

**THEORY**

**UNIT-I:** Concept of natural reserves and natural gene banks; *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ* conservation on-farm, building on farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

**UNIT-II:** *Ex situ* conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, perma-frost conservation, guidelines for seed multiplication and exchange to network of active/

working collections, orthodox, recalcitrant seeds - differences in handling, clonal repositories, genetic stability under long term storage condition.

**UNIT-III:** *In vitro* storage, maintenance of *in vitro* culture under different conditions, *in vitro* bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems, prospects of *in vitro* gene bank.

**UNIT-IV:** Cryopreservation- procedure for handling seeds of orthodox and recalcitrant cryoprotectants, desiccation, rapid freezing, slow freezing, vitrification techniques, encapsulation/ dehydration techniques, national facilities, achievements, application of cryopreservation in agricultural, horticultural and forestry crops. Problems and prospects; challenges ahead.

**UNIT-V:** Concept and procedure for PGR management, germplasm characterization, evaluation and utilization; Concept of core and mini core; collections and registration of plant germplasm.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Ellis, R. H., Roberts, E. H. & White, H. J. (1980). A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks. FAO / IBPGR Pl. Genet. Resources News 41-3-18.
2. Frankel, O. H. & Hawkes, J. G. (1975). Crop Genetic Resources for Today and Tomorrow. Cambridge University Press, Cambridge.
3. Paroda, R. S. and Arora, R. K. (1991). Plant Genetic Resource Conservation and Management, NBPGR, New-Delhi.
4. Simmonds, N. W. (1979). Principles of Crop Improvement. Longman.
5. Westwood, M. N. (1986). Operation Manual for National Clonal Germplasm Repository Processed Report. USDA-ARS and Oregon State University, Oregon, USA.
6. Withers, L. A. (1980). Tissue Culture Storage for Genetic Conservation. IBPGR Tech. Rep. IBPGR, Rome, Italy.

## GPB 627 POPULATION GENETICS 2 (2+0)

**WHY THIS COURSE?**

Population improvement programmes are the basis of genetic enhancement in cross pollinated crops. This course is needed to make the students aware about the population genetics and its role in crop improvement.

**AIM OF THE COURSE**

To impart knowledge on structure, properties and their breeding values of different population.

**COURSE OUTCOME**

After the completion of this course the student will be well versed with population genetics, its components and applications in crop improvement.

**THEORY**

**UNIT-I:** Population: Properties of population, Mendelian population; Genetic constitution of a population through time, space, age structure *etc.*; Frequencies of genes and genotypes; Causes of change: population size, differences in fertility and viability, migration and mutation.

**UNIT-II:** Hardy-Weinberg equilibrium, Hardy-Weinberg law, Proof and applications of the Hardy Weinberg law, Test of Hardy-Weinberg equilibrium; Mating frequencies: Non-dominance, Codominance, Snyder’s ratio, importance and its effect over random mating in succeeding generations.

**UNIT-III:** Multiple alleles, More than one locus, Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations - Changes of gene frequency, Migration, Mutation, Recurrent and non-recurrent Selection; Balance between selection and mutation; Selection favouring heterozygotes; Overdominance for fitness.

**UNIT-IV:** Mating systems, Random mating population, Non-random mating: selfing-inbreeding coefficient, panmictic index, sib mating, Assortative mating and disassortative mating; Pedigree populations and close inbreeding, Estimation of linkage disequilibrium, Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops; Gene substitution and average effects; Breeding value, Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis- Adaptive organization of gene pools; Polymorphism, Balanced and Non-balanced polymorphism, heterozygous advantage, Survival of recessive and deleterious alleles in populations.

**TEACHING METHODS**

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments/ quiz
- Group tasks, student's presentations.

**SUGGESTED READINGS**

1. Chawla, V. & Yadava, R. K. (2006). Principles of Population Genetics – A Practical Manual. Dept. of Genetics, CCS HAU Hisar.
2. Falconer, D. S. & Mackay, J. (1996). Introduction to Quantitative Genetics. Longman.
3. Jain, J. P., Jain, J. & Parbhakaran, V. T. (1992). Genetics of Populations. South Asia Books.
4. Li, C. C. (1955). Population Genetics. The Univ. of Chicago Press.
5. Mather, K. & Jinks, J. L. (1982). Biometrical Genetics. Chapman & Hall.
6. Sorrens, D. & Doniel, G. (2007). Methods in Quantitative Genetics Series: Statistics for Biology and Health. Likelihood.
7. Tomar, S. S. (1992). Text Book of Population Genetics. Universal Publication.

# DEPARTMENT OF HORTICULTURE
# AGRICULTURE UNIVERSITY, JODHPUR

**Semester Wise Course Title and Credits:**

| Code | Course title | Credit hours |
|---|---|---|
| | **M.Sc. (Hort.) Vegetable Science** | |
| **Semester-I** | | |
| VSC 511* | Production of Warm Season Vegetable Crops | 3(2+1) |
| VSC 512* | Growth and Development of Vegetable Crops | 3(2+1) |
| VSC 513* | Principles of Vegetable Breeding | 3(2+1) |
| **Semester-II** | | |
| VSC 521* | Production of Cool Season Vegetable Crops | 3(2+1) |
| VSC 522** | Protected Cultivation of Vegetable Crops | 3(2+1) |
| VSC 523# | Seed Production of Vegetable Crops | 3(2+1) |
| VSC 524# | Breeding of Self Pollinated Vegetable Crops | 3(2+1) |
| VSC 525# | Breeding of Cross Pollinated Vegetable Crops | 3(2+1) |
| VSC 526# | Systematics of Vegetable Crops | 2(1+1) |
| VSC 527# | Organic Vegetable Production | 2(1+1) |
| VSC 528# | Production of Spice Crops | 3(2+1) |
| **Semester-III** | | |
| VSC 531# | Postharvest Management of Vegetable Crops | 3(2+1) |
| VSC 532# | Production of Underutilized Vegetable Crops | 3(2+1) |
| VSC 533# | Processing of Vegetable Crops | 2(1+1) |
| | **Ph.D. Vegetable Science** | |
| **Semester-I** | | |
| VSC 611* | Recent Trends in Vegetable Production | 3(3+0) |
| VSC 612* | Advances in Breeding of Vegetable Crops | 3(3+0) |
| | **Semester-I** | |
| VSC 621# | Abiotic Stress Management in Vegetable Crops | 3(2+1) |
| VSC 622# | Seed Certification, Processing and Storage of Vegetable Seeds | 3(2+1) |
| VSC 623# | Breeding for Special Traits in Vegetable Crops | 2(2+0) |
| VSC 624# | Biodiversity and Conservation of Vegetable Crops | 3(2+1) |
| VSC 625# | Biotechnological Approaches in Vegetable Crops | 3(2+1) |
| VSC 626# | Advanced Laboratory Techniques for Vegetable Crops | 3(1+2) |

**Core courses* (External evaluation) ***Compulsory courses*(Internal evaluation) #*Optional courses*

**Semester Wise Course Title and Credits:**

| Code | Course title | Credit hours |
|---|---|---|
| | **M.Sc. (Hort.) Fruit Science** | |
| **Semester-I** | | |
| FSC 511* | Tropical Fruit Production | 3(2+1) |
| FSC 512* | Sub-Tropical and Temperate Fruit Production | 3(2+1) |
| FSC 513* | Propagation and Nursery Management of Fruit Crops | 3(2+1) |
| **Semester-II** | | |
| FSC 521* | Breeding of Fruit Crops | 3(2+1) |
| FSC 522# | Growth and Development of Fruit Crops | 3(2+1) |
| FSC 523# | Nutrition of Fruit Crops | 3(2+1) |
| FSC 524# | Systematics of Fruit Crops | 3(2+1) |
| FSC 525# | Canopy Management of Fruit Crops | 2(1+1) |
| FSC 526# | Biotechnology of Fruit Crops | 3(2+1) |
| FSC 527# | Organic Fruit Culture | 3(2+1) |
| **Semester-III** | | |
| FSC 531** | Minor Fruit Production | 3(2+1) |

| | | |
|---|---|---|
| FSC 532# | Export Oriented Fruit Production | 3(2+1) |
| FSC 533# | Climate Change and Fruit Crops | 1(1+0) |
| **Ph.D. Fruit Science** | | |
| **Semester-I** | | |
| FSC 611* | Innovative Approaches in Fruit Breeding | 3(3+0) |
| FSC 612* | Modern Trends in Fruit Production | 3(3+0) |
| **Semester-II** | | |
| FSC 621** | Abiotic Stress Management in Fruit Crops | 3(2+1) |
| FSC 622# | Recent Developments in Growth Regulation | 3(3+0) |
| FSC 623# | Arid and Dry Land Fruit Production | 2(2+0) |
| FSC 624# | Advanced Laboratory Techniques | 3(1+2) |
| FSC 625# | Biodiversity and Conservation of Fruit Crops | 3(2+1) |
| FSC 626# | Smart Fruit Production | 2(2+0) |

**Core courses* (External evaluation) *** Compulsory courses* (Internal evaluation) #*Optional courses* (Internal evaluation).

**Semester Wise Course Title and Credits:**

| Code | Course title | Credit hours |
|---|---|---|
| **M.Sc. (Hort.) Plantation, Spices, Medicinal and Aromatic Crops** | | |
| **Semester-I** | | |
| PSM 511* | Production of Plantation Crops | 3(2+1) |
| PSM 512* | Production of Spice Crops | 3(2+1) |
| PSM 513* | Production of Medicinal and Aromatic Crops | 3(2+1) |
| **Semester-II** | | |
| PSM 521* | Breeding of Plantation and Spice Crops | 3(2+1) |
| PSM 522** | Breeding of Medicinal and Aromatic Crops | 2(1+1) |
| PSM 523# | Underexploited Plantation, Spice, Medicinal and Aromatic Plants | 2(2+0) |
| PSM 524# | Growth and Development of Plantation, Spice, Medicinal and Aromatic Crops | 3(2+1) |
| PSM 525# | Systematics of Plantation and Spice Crops | 2(1+1) |
| **Semester-III** | | |
| PSM 531# | Biochemistry of Plantation, Spice, Medicinal and Aromatic crops | 3(2+1) |
| PSM 532# | Biodiversity and Conservation of Plantation, Spice, Medicinal and Aromatic Crops | 3(2+1) |
| PSM 533# | Systematics of Medicinal and Aromatic Crops | 2(1+1) |
| **Ph.D. Plantation, Spices, Medicinal and Aromatic Crops** | | |
| **Semester-I** | | |
| PSM 611* | Advances in Production of Plantation and Spice Crops | 3(3+0) |
| PSM 612* | Advances in Production of Medicinal and Aromatic Crops | 3(3+0) |
| **Semester-II** | | |
| PSM 621** | Recent Breeding Approaches in Plantation, Spice, Medicinal and Aromatic Crops | 3(3+0) |
| PSM 622# | Abiotic Stress Management in Plantation, Spice, Medicinal and Aromatic Crops | 3(2+1) |
| PSM 623# | Advances in Laboratory Techniques for PSMA Crops | 3(1+2) |
| PSM 624# | Biotechnological Approaches in PSMA Crops | 3(3+0) |
| PSM 625# | Organic Spice and Plantation Crops Production | 3(2+1) |
| PSM 626# | Marketing and Trade of Plantation, Spice, Medicinal and Aromatic Crops | 3(2+1) |

**Core courses* (External evaluation) ***Compulsory courses* (Internal evaluation) #*Optional courses* (Internal evaluation).

**Semester Wise Course Title and Credits:**

| Code | Course title | Credit hours |
|---|---|---|
| | **M.Sc. (Hort.) Floriculture and Landscaping** | |
| **Semester-I** | | |
| FLS 511* | Breeding of Ornamental Plants | 3(2+1) |
| FLS 512* | Ornamental Gardening and Landscaping | 3(2+1) |
| FLS 513* | Commercial Production of Loose Flowers | 3(2+1) |
| **Semester-II** | | |
| FLS 521* | Protected Cultivation of Flower Crops | 3(2+1) |
| FLS 522# | Nursery Management for Ornamental Plants | 3(2+1) |
| FLS 523# | Systematics of Ornamental Plants | 2(1+1) |
| FLS 524# | Commercial Production of Cut Flowers | 3(2+1) |
| FLS 525# | Indoor Plants and Interior scaping | 2(1+1) |
| FLS 526# | Seed Production in Flower Crops | 2(1+1) |
| **Semester-III** | | |
| FLS 531# | Value Addition in Floriculture | 3(2+1) |
| FLS 532# | Turf Grass Management | 3(2+1) |
| FLS 533# | CAD for Landscaping | 3(1+2) |
| | **Ph.D. Floriculture and Landscaping** | |
| **Semester-I** | | |
| FLS 611* | Crop Regulation in Ornamental Crops | 3(2+1) |
| FLS 612* | Postharvest Biology of Floricultural Crops | 3(2+1) |
| **Semester-II** | | |
| FLS 621** | Advances in Production Technology of Flower Crops | 3(2+1) |
| FLS 622# | Advances in Landscape Gardening | 3(1+2) |
| FLS 623# | Specialty Flowers, Fillers and Cut Greens | 2(1+1) |
| FLS 624# | Biotechnological Approaches in Floricultural Crops | 3(2+1) |
| FLS 625# | Vertical Gardening | 3(1+2) |
| FLS 626# | Advances in Breeding of Floricultural crops | 3(2+1) |
| FLS 627# | Advances in Protected Cultivation of Flower Crops | 3(2+1) |

**Core courses* (External evaluation) ***Compulsory courses* (Internal evaluation) #*Optional courses* (Internal evaluation).

**Semester Wise Course Title and Credits:**

| Code | Course title | Credit hours |
|---|---|---|
| | **M.Sc. (Hort.) Postharvest Management** | |
| **Semester-I** | | |
| PHM 511* | Postharvest Management of Horticultural Produce | 3(2+1) |
| PHM 512* | Postharvest Physiology and Biochemistry of Perishables | 3(2+1) |
| PHM 513* | Principles and Methods of Fruit And Vegetable Preservation | 3(2+1) |
| **Semester-II** | | |
| PHM 521* | Processing of Horticultural Produce | 4(2+2) |
| PHM 522# | Packaging and Storage of Fresh Horticultural Produce | 2(1+1) |
| PHM 523# | Laboratory Techniques in Postharvest Management | 3(1+2) |
| PHM 524# | Packaging and Storage of Processed Horticultural Produce | 2(1+1) |
| **Semester-III** | | |
| PHM 531** | Quality Assurance, Safety and Sensory Evaluation of Fresh and Processed Horticultural Produce | 3(2+1) |
| PHM 532# | Functional Foods from Horticultural Produce | 2(2+0) |
| PHM 533# | Marketing and Entrepreneurship in Postharvest Horticulture | 2(1+1) |
| | **Ph.D. Postharvest Management** | |
| **Semester-I** | | |
| PHM 611* | Ripening and Senescence of Fruits and Vegetables | 2(1+1) |
| PHM 612* | Recent Trends in Food Preservation | 2(1+1) |

| | | |
|---|---|---|
| PHM 613* | Supply Chain Management of Perishables | 2(2+0) |
| **Semester-II** | | |
| PHM 621** | Management and Utilization of Horticultural Processing Waste | 3(3+0) |
| PHM 622# | Export Oriented Horticulture | 1(1+0) |
| PHM 623# | Food Additives | 2(1+1) |
| PHM 624# | Advances in Processing of Plantation, Spices, Medicinal and Aromatic Plants | 3(3+0) |
| PHM 625# | Value Addition in Ornamental Crops | 2(1+1) |

**Core courses* (External evaluation) ***Compulsory courses #Optional courses* (Internal evaluation)

**The Minor and Supporting Courses and Research Programmes of the different specialized M.Sc. and Ph.D. degree programmes in Horticulture approved**:

| Programme | Seminar | Compre-hensive | Research | Minor/ supporting courses | Non-credit compulsory courses |
|---|---|---|---|---|---|
| M.Sc. (Hort.) Vegetable Science | VSC 591 | VSC 598 | VSC 599 | STAT 512 STAT 521, PP 513, PP 514, PP 523, PP 532, PP 533, ENTO 532 | PGS 501, PGS 502, PGS 503, PGS 504, PGS 505 |
| M.Sc. (Hort.) Fruit Science | FSC 591 | FSC 598 | FSC 599 | | |
| M.Sc. (Hort.) Floriculture & Landscaping | FLS 591 | FLS 598 | FLS 599 | | |
| M.Sc. (Hort.) PSMA Crops | PSM 591 | PSM 598 | PSM 599 | | |
| M.Sc. (Hort.) Postharvest Management | PHM 591 | PHM 598 | PHM 599 | | |
| Ph.D. Vegetable Science | VSC 691 VSC 692 | VSC 698 | VSC 699 | STAT 513, STAT 523, PP 513, PP 514, PP 523, PP 532, PP 533, MBB 511, MBB 521, MBB 525 | @[PGS 501, PGS 502, PGS 503, PGS 504 PGS 505] |
| Ph.D. Fruit Science | FSC 691 FSC 692 | FSC 698 | FSC 699 | | |
| Ph.D. Floriculture & Landscaping | FLS 691 FLS 692 | FLS 698 | FLS 699 | | |
| Ph.D. Plantation, Spices, Medicinal and Aromatic Crops | PSM 691 PSM 692 | PSM 698 | PSM 699 | | |
| Ph.D. Postharvest Management | PHM 691 PHM 692 | PHM 698 | PHM 699 | | |

*@If not studied during master's degree programme.*

*[Major optional/minor/supporting courses will be decided by the Advisory/Departmental Committee as per the requirement and available facilities. Deficiency courses (if any), may be opted as deemed suitable by the Advisory Committee.]*

**Semester wise break-up of Course Credit hours in the different specialized M.Sc. and Ph.D. programmes:**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Non-Credit Compulsory Courses | Seminar |
|---|---|---|---|---|---|
| **M.Sc. (Horticulture)** | | | | | |
| I | 3 (9) | 1 (3) | 1 (3) | 3 (3) | - |
| II | 2 (6) | 1 (3) | 1 (3) | 2 (2) | - |
| III | 2 (6) | 1 (3) | - | - | 1 |
| IV | **Masters Research** | | | | |
| **Ph.D.** | | | | | |
| I | 2 (6) | 1 (3) | 1 (3) | - | 1 |
| II | 2 (6) | 1 (3) | 1 (3) | - | 1 |
| III & onward | **Doctoral Research** | | | | |

§Total number as well as semester wise Credit hours/Courses may increase/decrease as per the requirement, as deemed suitable by the Advisory Committee; over and above the minimum credit requirements of BSMA.

**Examination pattern:**

| Particulars | Quiz/Assignment | Mid Term | Final Examination | |
|---|---|---|---|---|
| | | | **Theory** | **Practical** |
| Courses with Theory & Practical | 5 | 15 | 50 | 30 |
| Courses with only Theory | 5 | 15 | 80 | - |
| Courses with only Practical | 5 | 15 | - | 80 |

**Pattern for Comprehensive Exam of M.Sc. and Ph.D. degree programmes in Horticulture**:

The Written Comprehensive Exam will be followed by Oral Comprehensive Exam:

(i.) Written Exam: Maximum marks: 100 of each paper

M.Sc.: 2 papers (1 Major + 1 Supporting & Minor subjects)

Ph.D.: 3 papers (2 Major + 1 Supporting & Minor subjects)

Paper setting: Internal under the Chairmanship of HOD

Evaluation: Internal under the Chairmanship of HOD

Qualifying marks: M.Sc.: 60% individually Ph.D.: 65% individually

(ii.) Oral Exam: Maximum marks: 100

M.Sc.: Upon qualifying the Written Exam, Oral Exam is to be conducted by the Student's Advisory Committee in presence of HOD

Ph.D.: Upon qualifying the Written Exam, Oral Exam will be conducted by the Student's Advisory Committee in presence of HOD and External Examiner

*Grading of Comprehensive Exam (M.Sc. & Ph.D.): Satisfactory/Not Satisfactory*.

# COURSE CONTENTS: M.Sc. (Hort.) VEGETABLE SCIENCE

## VSC 511 PRODUCTION OF WARM SEASON VEGETABLE CROPS 3(2+1)

**WHY THIS COURSE?**

Unlike cool-season vegetables, warm-season vegetable crops require higher soil and air temperature, thus, they are always planted after the last frost date ranging from late spring after the last frost date to late summer. Daytime temperature may still be warm enough but drop so much at night-time that the weather is not suitable for warm-season crops any longer. In general summer vegetables require a little higher temperature than winter vegetables for optimum growth. In summer vegetables, the edible portion is mostly botanical fruit. The students of vegetable science need to have an understanding of production technology of important warm season vegetable crops and thereafter their management.

**AIM OF THIS COURSE**

To impart knowledge and skills on advancement in production technology of warm season vegetable crops

The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Production of warm season vegetable crops | 1. Fruit vegetables |
| | | 2. Beans |
| | | 3. Cucurbits |
| | | 4. Tuber crops |
| | | 5. Leafy vegetables |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:

1. Appreciate the scope and scenario of warm season vegetable crops in India
2. Acquire knowledge about the production technology and post-harvest handling of warm season vegetable crops
3. Calculate the economics of vegetable production in India

**THEORY**

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/hybrids, seed rate and seed treatment, raising of nursery including grafting technique, sowing/planting time and methods, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices namely hydroponics, aeroponics, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marking), pest and disease management and economics of crops.

**UNIT-I:** *Fruit vegetables*- Tomato, brinjal, hot pepper, sweet pepper and okra.

**UNIT-II:** *Beans*- French bean, Indian bean (Sem), cluster bean and cowpea.

**UNIT-III:** *Cucurbits*- Cucumber, melons (watermelon and muskmelon), gourds (bottle gourd, ridge gourd, bitter gourd, pointed gourd and round gourd), pumpkin and summer squash.

**UNIT-IV:** *Tuber crops*- Sweet potato, elephant foot yam, tapioca, taro and yam.

**UNIT-V:** *Leafy vegetables*- Amaranth and drumstick.

**PRACTICAL**

1. Scientific raising of nursery and seed treatment;
2. Sowing, transplanting, vegetable grafting;
3. Description of commercial varieties and hybrids;
4. Demonstration on methods of irrigation, fertilizers and micronutrients application;
5. Mulching practices, weed management;

6. Use of plant growth substances in warm season vegetable crops;
7. Study of nutritional and physiological disorders;
8. Studies on hydroponics, aeroponics and other soilless culture;
9. Identification of important pest and diseases and their control;
10. Preparation of cropping scheme for commercial farms;
11. Visit to commercial farm, greenhouse/polyhouses;
12. Visit to vegetable market;
13. Analysis of benefit to cost ratio.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedures
- Group discussion

**SUGGESTED READINGS**

1. Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G. 2003. *Vegetable Crops*. Vols. I-III. Naya udyog.
2. Bose, T.K., Som, M.G. and Kabir, J. (Eds.). 1993. *Vegetable Crops*. Naya prokash.
3. Chadha, K.L. and Kalloo, G. (Eds.). 1993. *Advances in Horticulture* Vols. V-X. Malhotra publ. house.
4. Chadha, K.L. (Ed.),.2002. *Handbook of Horticulture*. ICAR.
5. Chauhan, D.V.S. (Ed.). 1986. *Vegetable Production in India*. Ram prasad and sons.
6. Fageria, M.S., Choudhary, B.R. and Dhaka, R.S. 2000. *Vegetable Crops: Production Technology*. Vol. II. Kalyani.
7. Gopalakrishanan, T.R. 2007. *Vegetable Crops*. New India publ. agency.
8. Hazra, P. and Banerjee, M. K. and Chattopadhyay, A. 2012. *Varieties of Vegetable Crops in India* (2nd ed.), Kalyani publishers, Ludhiana , 199 p
9. Hazra, P. 2016. *Vegetable Science*. 2nd ed, Kalyani publishers, Ludhiana.
10. Hazra, P. 2019. *Vegetable Production and Technology*. NIPA, New Delhi.
11. Hazra, P., Chattopadhyay, A., Karmakar, K. and Dutta, S. 2011. *Modern Technology for Vegetable Production.* New India publishing agency, New Delhi, 413p
12. Rana, M.K. 2008. *Olericulture in India*. Kalyani publ.
13. Rana, M.K. 2008. *Scientific Cultivation of Vegetables*. Kalyani publ.
14. Rubatzky, V.E. and Yamaguchi, M. (Eds.) 1997. *World Vegetables: Principles, Production and Nutritive Value*s. Chapman and Hall.
15. Saini, G.S. 2001. *A Textbook of Oleri and Floriculture*. Aman publishing house.
16. Salunkhe, D.K. and Kadam, S.S. (Ed.). 1998. *Handbook of Vegetable Science and Technology: Production, Composition, Storage and Processing*. Marcel dekker.
17. Shanmugavelu, K.G. 1989. *Production Technology of Vegetable Crops*. Oxford and IBH.
18. Singh, D.K. 2007. *Modern Vegetable Varieties and Production Technology*. IBDC
19. Singh, S.P. (Ed.). 1989. *Production Technology of Vegetable Crops*. Agril. comm. res. centre.
20. Thamburaj, S. and Singh, N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.
21. Thompson, H.C. and Kelly, W.C. (Eds.) 1978. *Vegetable Crops*. Tata McGraw-Hill.

## VSC 512 GROWTH AND DEVELOPMENT OF VEGETABLE CROPS 3(2+1)

**WHY THIS COURSE?**

In agriculture, the term plant growth and development is often substituted with crop growth and yield since agriculture is mainly concerned with crops and their economic products. Growth, which is irreversible quantitative increase in size, mass, and/or volume of a plant or its parts, occurs with an expenditure of metabolic energy. Plant development is an overall term, which refers to various changes that occur during its life cycle. In vegetable crops, development is a series of processes from the initiation of growth to death of a plant or its parts. Growth and development are sometimes used interchangeably in conversation, but in a botanical sense, they describe separate events in the organization of the mature plant body. The students of vegetable science need to have an understanding of growth and development of vegetable crops.

**AIM OF THIS COURSE**

To teach the physiology of growth and development of vegetable crops. The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Growth and development of vegetable crops | 1. Introduction and phytohormones |
| | | 2. Physiology of dormancy and germination |
| | | 3. Abiotic factors |
| | | 4. Fruit physiology |
| | | 5. Morphogenesis and tissue culture |

**COURSE OUTCOMES:**

After successful completion of this course, the students are expected to:
1. Acquire knowledge about the growth and development of plants in vegetable crops.
2. Distinguish between primary and secondary growth in plant stems.
3. Understand how hormones affect the growth and development of vegetable crops.

**THEORY**

**UNIT-I:** *Introduction and phytohormones*- Definition of growth and development; Cellular structures and their functions; Physiology of phyto-hormones functioning/biosynthesis and mode of action; Growth analysis and its importance in vegetable production

**UNIT-II:** *Physiology of dormancy and germination*- Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellilns, cyktokinins and abscissic acid; Application of synthetic PGRs including plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production

**UNIT-III:** *Abiotic factors*- Impact of light, temperature, photoperiod, carbon dioxide, oxygen and other gases on growth, development of underground parts, flowering and sex expression in vegetable crops; Apical dominance

**UNIT-IV:** *Fruit physiology*- Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening

**UNIT-V:** *Morphogenesis and tissue culture*- Morphogenesis and tissue culture techniques in vegetable crops; Grafting techniques in different vegetable crops

**PRACTICAL**

1. Preparation of plant growth regulator's solutions and their application;
2. Experiments in breaking and induction of dormancy by chemicals;
3. Induction of parthenocarpy and fruit ripening;
4. Application of plant growth substances for improving flower initiation, changing sex expression in cucurbits and checking flower and fruit drops and improving fruit set in solanaceous vegetables;
5. Growth analysis techniques in vegetable crops;
6. Grafting techniques in tomato, brinjal, cucumber and sweet pepper.

**TEACHING METHODS/ACTIVITIES:**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedure
- Group discussion

**SUGGESTED READINGS**

1. Bleasdale, J.K.A. 1984. *Plant Physiology in Relation to Horticulture* (2nd Ed.) MacMillan.
2. Gupta, U.S., Eds. 1978. *Crop Physiology*. Oxford and IBH, New Delhi.
3. Kalloo, G. 2017. *Vegetable Grafting: Principles and Practices*. CAB International

4. Krishnamoorti, H.N. 1981. *Application Growth Substances and Their Uses in Agriculture*. Tata MG Hill.
5. Leopold, A.C. and Kriedemann, P.E. 1981. *Plant Growth and Development*. Tata McGraw-Hill, Delhi.
6. Peter, K.V. and Hazra, P. (Eds). 2012. *Handbook of Vegetables*. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p
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## VSC 513 PRINCIPLES OF VEGETABLE BREEDING 3(2+1)

**WHY THIS COURSE?**

Plant breeding has been practiced for thousands of years, since beginning of human civilization. Vegetable breeding, which is an art and science of changing the traits of plants in order to produce desired traits, has been used to improve the quality of nutrition in products for human beings. A breeding programme, which is needed if current varieties are not producing up to the capacity of the environment, can be accomplished through many different techniques ranging from simply selecting plants with desirable characteristics, make use of knowledge of genetics and chromosomes to more complex molecular techniques. When different genotypes exhibit differential responses to different sets of environmental conditions, a genotype x environment (GxE) interaction is said to occur. Breeding high yielding open pollinated varieties and hybrids, and exploitation of location specific component of genotypic performance are the only options left to reduce this increasing gap between the production and requirements in view of decreasing land resources. Nevertheless, vegetable breeding is an integral part of plant breeding but this will be remodelled to suit to breeding of different vegetables crops. The students of vegetable science who are having breeding as major subject need to have an understanding of vegetable breeding principles.

**AIM OF THIS COURSE**

To teach basic principles and practices of vegetable breeding
The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Principles of vegetable breeding | 1. Importance and history |
| | | 2. Selection procedures |
| | | 3. Heterosis breeding |
| | | 4. Mutation breeding |
| | | 5. Polyploid breeding |
| | | 6. Ideotype breeding |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:
1. Acquire knowledge about the principles of vegetable breeding
2. Improve yield, quality, abiotic and biotic resistance, other important traits of vegetable crops
3. Understand how the basic principles are important to start breeding of vegetable crops

**THEORY**

**UNIT-I:** *Importance and history*- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding

**UNIT-II:** *Selection procedures*- Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture; Breeding for biotic stress (diseases, insect pests and nematode), abiotic stress (temperature, moisture and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE)

**UNIT-III:** *Heterosis breeding-* Types, mechanisms and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility and sex forms

**UNIT-IV:** *Mutation and Polyploidy breeding;* Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment

**UNIT-V:** *Ideotype breeding-* Ideotype breeding; varietal release procedure; DUS testing in vegetable crops; Application of In vitro and molecular techniques in vegetable improvement

**PRACTICAL**

1. Floral biology and pollination behaviour of different vegetables;
2. Techniques of selfing and crossing of different vegetables *viz.*, Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, *etc.*;
3. Breeding system and handling of filial generations of different vegetables;
4. Exposure to biotechnological lab practices;
5. Visit to breeding farms;

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedures
- Group discussion

**SUGGESTED READINGS**


1. Allard, R.W. 1960. *Principle of Plant Breeding*. John Willey and Sons, USA.
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6. Singh, B.D. 2007. *Plant Breeding- Principles and Methods* (8th ed.). Kalyani Publishers.
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## VSC 521 PRODUCTION OF COOL SEASON VEGETABLE CROPS 3(2+1)

**WHY THIS COURSE?**

Cool season vegetables are a major source of dietary fibres, minerals and vitamins. Some of these vegetables also contribute protein, fat and carbohydrate. Most of the leafy and root vegetables are rich in minerals, especially in micro-elements such as copper, manganese and zinc. Vegetables differ in their temperature requirement for proper growth and development. Most of the winter vegetable crops are cultivated in cool season when the monthly mean temperature does not exceed 21°C. Even in temperate climate, these vegetables are cultivated in spring summer in hilly tracks where the daytime temperature in summer is less than 21°C. The students of vegetable science need to have an understanding of production technology of important cool season vegetable crops and their management.

**AIM OF THIS COURSE**

To impart knowledge and skills on advancement in production technology of cool season vegetable crops

The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Production of cool season vegetable crops | 1. Bulb and tuber crops |
| | | 2. Cole crops |
| | | 3. Root crops |
| | | 4. Peas and beans |
| | | 5. Leafy vegetables |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:

1. Appreciate the scope and scenario of cool season vegetable crops in India
2. Acquire knowledge about the production technology and post-harvest handling of cool season vegetable crops
3. Calculate the economics of vegetable production in India

**THEORY**

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/hybrids, seed rate and seed treatment, raising of nursery, sowing/planting time and methods, hydroponics and aeroponics, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of crops.

**UNIT-I:** *Bulb and tuber crops*- Onion, garlic and potato

**UNIT-II:** *Cole crops*- Cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and kale

**UNIT-III:** *Root crops*- Carrot, radish, turnip and beetroot

**UNIT-IV:** *Peas and beans*- Garden pea and broad bean

**UNIT-V:** *Leafy vegetables*- beet leaf, fenugreek, coriander and lettuce

**PRACTICAL**

1. Scientific raising of nursery and seed treatment;
2. Sowing and transplanting;
3. Description of commercial varieties and hybrids;
4. Demonstration on methods of irrigation, fertilizers and micronutrients application;
5. Mulching practices, weed management;
6. Use of plant growth substances in cool season vegetable crops;
7. Study of nutritional and physiological disorders;
8. Studies on hydroponics, aeroponics and other soilless culture;
9. Identification of important pest and diseases and their control;
10. Preparation of cropping scheme for commercial farms;
11. Visit to commercial farm, greenhouse/polyhouses;
12. Visit to vegetable market;
13. Analysis of benefit to cost ratio.

**TEACHING METHODS/ACTIVITIES**

- Classroom lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedures
- Group discussion

**SUGGESTED READINGS**


1. Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G. 2003. *Vegetable Crops*. Vols. **I-III**. Naya udyog.
2. Bose, T.K., Som, M.G. and Kabir, J. (Eds.). 1993. *Vegetable Crops*. Naya prokash.
3. Chadha, K.L. and Kalloo, G. (Eds.). 1993-94. *Advances in Horticulture* Vols. **V-X**. Malhotra publ. house.
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12. Rana, M.K. 2008. *Olericulture in India*. Kalyani publ.
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16. Saini, G.S. 2001. *A Textbook of Oleri and Floriculture*. Aman publishing house.
17. Salunkhe, D.K. and Kadam, S.S. (Ed.). 1998. *Handbook of Vegetable Science and Technology: Production, Composition, Storage and Processing*. Marcel dekker.
18. Shanmugavelu, K.G. 1989. *Production Technology of Vegetable Crops*. Oxford and IBH.
19. Singh, D.K. 2007. *Modern Vegetable Varieties and Production Technology*. IBDC.
20. Singh, S.P. (Ed.). 1989. *Production Technology of Vegetable Crops*. Agril. comm. res. centre.
21. Thamburaj, S. and Singh, N. (Eds.). 2004. *Vegetables, Tuber crops and Spices*. ICAR.
22. Thompson, H.C. and Kelly, W.C. (Eds.). 1978. *Vegetable Crops*. Tata McGraw-Hill.

## VSC 522 PROTECTED CULTIVATION OF VEGETABLE CROPS 3(2+1)

**WHY THIS COURSE?**

India is the second largest producer of vegetable crops in the world. However, its vegetable production is much less than the requirement, if a balanced diet is provided to every individual. There are different ways and means to achieve this target. Protected cultivation, which is the modification of the natural environment to achieve optimum plant growth. Is the most intensive form of crop production with a yield per unit area up to ten times superior to that of a field crop. During winter under north-east Indian conditions, it is difficult to grow tomato, capsicum, cucurbits, French bean, amaranth, *etc.* in open field. However, various types of protected structure have been developed for growing some high value crops by providing protection from the excessive cold. Production of off-season vegetable nurseries under protected structure has become a profitable business. The main purpose of raising nursery plants in protected structure is to get higher profit and disease free seedlings in off-season to raise early crop in protected and open field condition. The low cost polyhouse is economical for small and marginal farmers, who cannot afford huge cost of high-tech polyhouse. Besides supplying the local markets, the production of polyhouse vegetables is greatly valued for its export potential and plays an important role in the foreign trade balance of several national economies. The students of vegetable science need to have an understanding of protected cultivation of vegetable crops.

**AIM OF THIS COURSE**

To impart latest knowledge about growing of vegetable crops under protected environmental conditions.

The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Protected cultivation of vegetable crops | 1. Scope and importance |
| | | 2. Types of protected structure |
| | | 3. Abiotic factors |
| | | 4. Nursery raising |
| | | 5. Cultivation of crops |
| | | 6. Solutions to problems |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:

1. Appreciate the scope and scenario of protected cultivation of vegetable crops in India.
2. Acquire knowledge about the effect of abiotic factors on growth, flowering and production of vegetable crops.
3. Gaining knowledge about the designing of various low cost protected structures.
4. Adopting the raising of vegetable seedlings in low cost protected structures as entrepreneur.

**THEORY**

**UNIT-I:** *Scope and importance*- Concept, scope and importance of protected cultivation of vegetable crops; Principles, design, orientation of structure, low and high cost polyhouses/greenhouse structures.

**UNIT-II:** *Types of protected structure*- Classification and types of protected structures greenhouse/ polyhouses, plastic-non plastic low tunnels, plastic walk in tunnels, high roof tunnels with ventilation, insect proof net houses, shed net houses, rain shelters, NVP, climate control greenhouses, hydroponics and aeroponics; Soil and soilless media for bed preparation; Design and installation of drip irrigation and fertigation system.

**UNIT-III:** *Abiotic factors*- Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity, *etc.* on growth and yield of different vegetables.

**UNIT-IV:** *Nursery raising*- High tech vegetable nursery raising in protected structures using plugs and portrays, different media for growing nursery under protected cultivation; Nursery problems and management technologies including fertigation.

**UNIT-V:** *Cultivation of crops*- Regulation of flowering and fruiting in vegetable crops; Technology for raising tomato, sweet pepper, cucumber, lettuce and red cabbage in protected structures, including varieties and hybrids, training, pruning and staking in growing vegetables under protected structures. Off-season cultivation of vegetables.

**UNIT-VI:** *Solutions to problems*- Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for seed production; Economics of greenhouse crop production.

**PRACTICAL**

1. Study of various types of protected structure;
2. Study of different methods to control temperature, carbon dioxide and light;
3. Study of different types of growing media, training and pruning systems in greenhouse crops;
4. Study of fertigation and nutrient management under protected structures;
5. Study of insect pests and diseases in greenhouse and its control;
6. Use of protected structures in hybrid seed production of vegetables;
7. Economics of protected cultivation (Any one crop);
8. Visit to established green/polyhouses/shade net houses in the region.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedures
- Group discussion

**SUGGESTED READINGS**

1. Chadha, K.L. and Kalloo, G. (Eds.). 1993. *Advances in Horticulture*. Malhotra Pub. House.
2. Chandra, S. and Som, V. 2000. *Cultivating vegetables in green house*. Indian Horticulture 45:17-18.
3. Kalloo, G. and Singh, K. (Eds.). 2000. *Emerging scenario in vegetable research and development*. Research periodicals and Book publ. house.
4. Parvatha, R. P. 2016. *Sustainable crop protection under protected cultivation.* E-Book Springer.
5. Prasad, S. and Kumar, U. 2005. *Greenhouse management for horticultural crops.* 2nd Ed. Agrobios.
6. Resh, H.M. 2012. *Hydroponic food production*. 7thEdn. CRC Press.
7. Singh, B. 2005. *Protected cultivation of vegetable crops*. Kalyani publishers, New Delhi
8. Singh, D.K. and Peter, K.V. 2014. *Protected cultivation of horticultural crops.* NIPA, New Delhi.
9. Singh, S., Singh, B. and Sabir, N. 2014. *Advances in protected cultivation.* NIPA, New Delhi.
10. Tiwari, G.N. 2003. *Green house technology for controlled environment*. Narosa publ. house.

## VSC 523 SEED PRODUCTION OF VEGETABLE CROPS 3(2+1)

**WHY THIS COURSE?**

Enhancing yield and quality of vegetable crops depends upon a number of factors. The inputs like fertilizers, irrigation and plant protection measures and suitable agronomic practices contribute greatly towards improving yield and quality of the vegetable produce. If good quality seed is not used, the full benefits of such inputs and agronomic practices cannot be realized. The use of high quality seed thus, plays a pivotal role in the production of vegetable crops. It is, therefore, important to use the seed conforming to the prescribed standards. A good quality seed should have high genetic and physical purity, proper moisture content and good germination. It should also be free from seed borne diseases and weed seeds. The quality of the produce will deteriorate if these factors are overlooked. Out crossing, physical admixtures and mutations are the prime factors responsible for the deterioration of seed quality. A variety could be saved from deterioration if proper checks are made at different stages of seed multiplication. It is also extremely important to maintain high genetic purity of a variety. The students of vegetable science need to have an understanding of seed production technology of vegetable crops and their essential processing before supplying them to the market or further use.

**AIM OF THIS COURSE**

To impart a comprehensive knowledge and skills on quality seed production of vegetable crops

The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Seed production of vegetable crops | 1. Introduction, history, propagation and reproduction |
| | | 2. Agro-climate and methods of seed production |
| | | 3. Seed multiplication and its quality maintenance |
| | | 4. Seed harvesting, extraction and its processing |
| | | 5. Improved agro-techniques and field and seed standards |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:

1. Appreciate the scope and scenario of seed production of vegetable crops in India
2. Acquire knowledge about the complete seed production technology, extraction and post extraction processing of vegetable seeds
3. Adoption of seed production of vegetable crops as entrepreneur

**THEORY**

**UNIT-I:** *Introduction, history, propagation and reproduction-* Introduction, definition of seed and its quality, seed morphology, development and maturation; Apomixis and fertilization; Modes of propagation and reproductive behaviour; Pollination mechanisms and sex forms in vegetables; History of vegetable seed production; Status and share of vegetable seeds in seed industry

**UNIT-II:** *Agro-climate and methods of seed production-* Agro-climate and its influence on quality seed production; Deterioration of crop varieties, genetical and agronomic principles of vegetable seed production; Methods of seed production, hybrid seeds and techniques of large scale hybrid seed production; Seed village concept

**UNIT-III:** *Seed multiplication and its quality maintenance-* Seed multiplication ratios and replacement rates in vegetables; Generation system of seed multiplication; Maintenance and production of nucleus, breeder, foundation, certified/ truthful label seeds; Seed quality and mechanisms of genetic purity testing

**UNIT-IV:** *Seed harvesting, extraction and its processing-* Maturity standards; Seed harvesting, curing and extraction; Seed processing viz., cleaning, drying and treatment of seeds, seed health and quality enhancement, packaging and marketing; Principles of seed storage; Orthodox and recalcitrant seeds; Seed dormancy

**UNIT-V:** *Improved agro-techniques and field and seed standards-* Improved agro-techniques; Field and seed standards in important solanaceous (tomato, brinjal, chilli and capsicum), leguminous and cucurbitaceous vegetables, cole crops (cabbage, cauliflower & knolkhol), leafy vegetables (coriander, fenugreek and beet leaf) bulbous (onion and garlic) and root crops (radish, carrot, turnip and beet root) and okra; clonal propagation and multiplication in vegetative propagated crops; Seed plot technique and true potato seed production in potato.

**PRACTICAL**

1. Study of floral biology and pollination mechanisms in vegetables;
2. Determination of modes of pollination;
3. Field and seed standards;
4. Use of pollination control mechanisms in hybrid seed production of important vegetables;
5. Maturity standards and seed extraction methods;
6. Seed sampling and testing;
7. Visit to commercial seed production areas;
8. Visit to seed processing plant;
9. Visit to seed testing laboratories.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedures
- Group discussion

**SUGGESTED READINGS**


1. Agarwaal, P. K. and Anuradha, V. 2018. *Fundamentals of seed science and technology*. Brilliant publications, New Delhi.
2. Agrawal, P.K. and Dadlani M. (Eds.). 1992. *Techniques in seed science and technology*. South Asian Publ.
3. Agrawal, R.L. (Ed.) 1997. *Seed technology*. Oxford and IBH.
4. Basra, A.S. 2000. *Hybrid seed production in vegetables*. CRC press, Florida, USA.
5. Bench, A.L.R. and Sanchez, R.A. 2004. *Handbook of seed physiology*. Food products press, NY/ London.
6. Bendell, P.E. (Eds.) 1998. *Seed science and technology*: Indian forestry species. Allied Publ.
7. Chakraborty, S.K., Prakash, S., Sharma, S.P. and Dadlani, M. 2002. *Testing of distinctiveness, uniformity and stability for plant variety protection*. IARI, New Delhi
8. Copland, L.O. and McDonald, M.B. 2004. *Seed science and technology*. Kluwer Academic Press.
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10. George, R.A. T. 1999. *Vegetable seed production* (2nd Edition). CAB International.
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13. Kumar, J.C. and Dhaliwal, M.S. 1990. *Techniques of developing hybrids in vegetable crops*. Agro botanical publ.
14. More, T.A., Kale, P.B. and Khule, B.W. 1996. *Vegetable seed production technology*. Maharashtra state seed corp.
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17. Singh, S.P. 2001. *Seed production of commercial vegetables*. Agrotech publ. academy.
18. Singhal, N.C. 2003. *Hybrid seed production*. Kalyani publishers, New Delhi.


## VSC 524 BREEDING OF SELF POLLINATED VEGETABLE CROPS 3(2+1)

**WHY THIS COURSE?**

Self-pollination, which is considered the highest degree of inbreeding a plant can achieve, promotes homozygosity of all gene loci and traits of the sporophyte and restricts the creation of new gene combinations (no introgression of new genes through hybridization). The progeny of a single plant is homogeneous due to self-pollination. A population of self-pollinated species comprises a mixture of homozygous lines. New genes may arise through mutation but such change is restricted to individual lines or the progenies of the mutant plant. Since a self-pollinated cultivar is generally one single genotype reproducing itself, breeding of self-pollinated species usually entails identifying one superior genotype (or a few) and its multiplication. Specific breeding methods commonly used for self-pollinated species are pure-line selection, pedigree breeding, bulk populations and backcross breeding. The students of vegetable science who take breeding as a minor subject need to have an understanding of breeding of self-pollinated vegetable crops.

**AIM OF THIS COURSE**

To impart comprehensive knowledge about principles and practices of breeding of self-pollinated vegetable crops

The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Breeding of self-pollinated vegetable crops | 1. Potato |
| | | 2. Fruit vegetables |
| | | 3. Garden peas and cowpea |
| | | 4. Beans |
| | | 5. Leafy vegetables |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:

1. Acquire knowledge about the breeding of self-pollinated vegetable crops
2. Improve yield, quality, abiotic and biotic resistance and other important traits of vegetable crops
3. Understand how to start the breeding of self-pollinated vegetable crops

**THEORY**

Origin, botany, taxonomy, wild relatives, cytogenetics and genetics, types of pollination and fertilization mechanism, sterility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation and polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stresses, breeding for protected environment and quality improvement, molecular markers and marker's assisted breeding; QTLs, PPV and FR Act.

**UNIT-I:** *Tuber crops:* Potato

**UNIT-II:** *Fruit vegetables*- Tomato, eggplant, hot pepper, sweet pepper and okra

**UNIT-III:** *Leguminous vegetables*- Garden pea and cowpea

**UNIT-IV:** *Leguminous vegetables:* French bean, Indian bean, cluster bean and broad bean

**UNIT-V:** *Leafy vegetables*- Lettuce and fenugreek

**PRACTICAL**

1. Floral mechanisms favouring self and often cross pollination;
2. Progeny testing and development of inbred lines;
3. Selection of desirable plants from breeding population, observations and analysis of various; qualitative and quantitative traits in germplasm, hybrids and segregating generations;
4. Palynological studies, selfing and crossing techniques;
5. Hybrid seed production of vegetable crops in bulk;
6. Screening techniques for biotic and abiotic stress resistance in above mentioned crops;
7. Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques;
8. Visit to breeding farms.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedures
- Group discussion

**SUGGESTED READINGS**


1. Allard, R.W. 1999. *Principles of Plant Breeding*. John Wiley and Sons.
2. Basset, M.J. (Ed.) 1986. *Breeding Vegetable Crops*. AVI Publ.
3. Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J. 2005. *Plant genetic resources: Horticultural crops*. Narosa Publ. House.
4. Fageria, M.S., Arya, P.S. and Choudhary, A.K. 2000. *Vegetable crops: Breeding and seed production*. Vol. **I**. Kalyani.
5. Gardner, E.J. 1975. *Principles of Genetics*. John Wiley and Sons.
6. Hayes, H.K., Immer, F.R. and Smith, D.C. 1955. *Methods of Plant Breeding*. McGraw-Hill.
7. Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.) 1993. *Plant Breeding- Principles and prospects*. Chapman and Hall.
8. Hazra, P. and Som, M.G. 2015. *Vegetable Science* (2nd ed.), Kalyani publishers, p598
9. Hazra, P. and Som, M.G. 2016. *Vegetable seed production and hybrid technology* (2nd ed.), Kalyani 459 p
10. Kalloo, G. 1988. *Vegetable breeding*. Vols. I-III. CRC Press.
11. Kalloo, G. 1998. *Vegetable breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
12. Kumar, J.C. and Dhaliwal, M.S. 1990. *Techniques of developing hybrids in vegetable crops*. Agro Botanical Publ.
13. Paroda, R.S. and Kalloo, G. (Eds.) 1995. *Vegetable research with special reference to hybrid technology in Asia-Pacific Region*. FAO.
14. Peter, K.V. and Pradeep Kumar, T. 2008. *Genetics and breeding of vegetables*. Revised, ICAR.
15. Peter, K.V. and Hazra, P. (Eds). 2012. *Handbook of vegetables*. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p
16. Peter, K.V. and Hazra, P. (Eds). 2015. *Handbook of vegetables*, Volume II. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
17. Peter, K.V. and Hazra, P. (Eds). 2015. *Handbook of vegetables,* Volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
18. Rai, N. and Rai, M. 2006. *Heterosis breeding in vegetable crops*. New India Publ. Agency.
19. Ram, H.H. 1998. *Vegetable breeding: principles and practices*. Kalyani Publ.
20. Simmonds, N.W. 1978. *Principles of crop improvement*. Longman.
21. Singh BD. 1983. *Plant Breeding*. Kalyani Publ.
22. Singh, P.K., Dasgupta, S.K. and Tripathi, S.K. 2004. *Hybrid Vegetable Development*. IBDC
23. Swarup, V. 1976. *Breeding Procedure for Cross-Pollinated Vegetable Crops*. ICAR.


## VSC 525 BREEDING OF CROSS POLLINATED VEGETABLE CROPS 3(2+1)

**WHY THIS COURSE?**

The important methods of breeding in cross-pollinated vegetable species are (i) mass selection, (ii) development of hybrid varieties and (ii) development of synthetic varieties. Since cross-pollinated vegetable crops are naturally hybrid (heterozygous) for many traits and lose vigour as they become purebred (homozygous), a goal of each of these breeding methods is to preserve or restore heterozygosity in cross pollinated vegetable crops. The students of vegetable science who take breeding as a minor subject need to have an understanding of breeding of cross pollinated vegetable crops.

**AIM OF THIS COURSE**

To impart comprehensive knowledge about principles and practices of cross pollinated vegetable crops breeding.

The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Breeding of cross pollinated vegetable crops | 1. Cucurbitaceous crops |
| | | 2. Cole crops |
| | | 3. Root and bulb crops |
| | | 4. Tuber crops |
| | | 5. Leafy vegetables |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:

1. Acquire knowledge about the breeding of cross pollinated vegetable crops
2. Improve yield, quality, abiotic and biotic resistance, and important traits of cross pollinated vegetable crops
3. Understand how to start the breeding of cross pollinated vegetable crops

**THEORY**

Origin, botany, taxonomy, cytogenetics, genetics, types of pollination and fertilization, mechanism, sterility and incompatibility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation, polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stresses, quality improvement, molecular markers and marker assisted breeding, and QTLs, PPV and FR act

**UNIT-I:** *Cucurbitaceous crops*- Gourds, melons, cucumber, pumpkin and squashes

**UNIT-II:** *Cole crops*- Cauliflower, cabbage, kohlrabi, broccoli and brussels sprouts

**UNIT-III:** *Root and bulb crops*- Carrot, radish, turnip, beet root and onion

**UNIT-IV:** *Tuber crops*- Sweet potato, tapioca, taro and yam

**UNIT-V:** *Leafy vegetables*- Beet leaf, spinach, amaranth and coriander

**PRACTICAL**

1. Floral mechanisms favouring cross pollination;
2. Development of inbred lines;
3. Selection of desirable plants from breeding population;
4. Observations and analysis of various quantitative and qualitative traits in germplasm, hybrids and segregating generations;
5. Induction of flowering, palynological studies, selfing and crossing techniques;
6. Hybrid seed production of vegetable crops in bulk; Screening techniques for biotic and abiotic stress resistance in above mentioned crops;
7. Demonstration of sib-mating and mixed population;
8. Molecular marker techniques to identify useful traits in vegetable crops and special breeding techniques;
9. Visit to breeding blocks.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation individual or in group
- Hands on training of different procedures
- Group discussion

**SUGGESTED READINGS**

1. Allard, R.W. 1999. *Principles of plant breeding*. John Wiley and Sons.
2. Basset, M.J. (Ed.). 1986. *Breeding vegetable crops*. AVI Publ.
3. Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J. 2005. *Plant genetic resources: Horticultural crops*. Narosa publ. house.
4. Fageria, M.S., Arya, P.S. and Choudhary, A.K. 2000. *Vegetable crops: Breeding and seed production.* Vol. **I**. Kalyani.
5. Gardner, E.J. 1975. *Principles of genetics*. John Wiley and Sons.
6. Hayes, H.K., Immer, F.R. and Smith, D.C. 1955. *Methods of plant breeding*. McGraw-Hill.
7. Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.). 1993. *Plant breeding- Principles and prospects.* Chapman and Hall.
8. Hazra, P. and Som M.G. 2015. *Vegetable science* (2nd ed.), Kalyani publishers, Ludhiana, 598 p
9. Hazra, P. and Som, M.G. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani Publishers, Ludhiana, 459 p
10. Kalloo, G. 1988 *Vegetable breeding*. Vols. I-III. CRC Press.
11. Kalloo, G. 1998. *Vegetable breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.

12. Kumar, J.C. and Dhaliwal, M.S. 1990. *Techniques of developing hybrids in vegetable crops*. Agro botanical publ.
13. Paroda, R.S. and Kalloo, G. (Eds.). 1995. *Vegetable research with special reference to hybrid technology in Asia-Pacific region*. FAO.
14. Peter, K.V. and Pradeep Kumar, T. 2008. *Genetics and breeding of vegetables*. Revised, ICAR.
15. Peter, K.V. and Hazra, P. (Eds). 2012. *Handbook of vegetables*. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p
16. Peter, K.V. and Hazra, P. (Eds) 2015. *Handbook of vegetables*, Volume II and III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
17. Rai, N. and Rai, M. 2006. *Heterosis breeding in vegetable crops*. New India Publ. Agency.
18. Prohens, J. and Nuez, F. 2007. *Handbook of Plant Breeding- Vegetables* (Vol. I and II), Springer, USA.
19. Ram, H.H. 1998. *Vegetable breeding: principles and practices*. Kalyani Publ.
20. Simmonds, N.W. 1978. *Principles of crop improvement*. Longman.
21. Singh, B.D. 1983. *Plant breeding*. Kalyani Publ.
22. Singh, P.K., Dasgupta, S.K. and Tripathi, S.K. 2004. *Hybrid vegetable development*. IBDC
23. Swarup, V. 1976. *Breeding procedure for cross-pollinated vegetable crops*. ICAR.

## VSC 526 SYSTEMATICS OF VEGETABLE CROPS 2(1+1)

**WHY THIS COURSE?**

Systematics is fundamental to our understanding of the world around us as it provides basis for understanding the patterns of diversity on earth. Vegetable systematics is the science of botanical diversity of vegetable crops on earth, including variation from the level of genes within an individual to individuals, populations and species. The primary aim of systematics is to discover all the branches of the tree of life, document evolutionary changes occurring along those branches, and describe all the species on earth (the tips of the branches). The secondary aim of systematic is to analyze and synthesize information into a classification that reflects evolutionary relationships, to organize this information into a useful, retrievable form to gain insight into evolutionary processes that lead to diversity.

**AIM OF THIS COURSE**

To impart knowledge on morphological, cytological and molecular taxonomy of vegetable crops.

The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Systematics of vegetable crops | 1. Significance of systematics |
| | | 2. Origin and evolution |
| | | 3. Botanical and morphological description |
| | | 4. Cytology |
| | | 5. Molecular markers |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:

1. Acquire knowledge on identification, description, classification and maintenance of vegetable species and varieties
2. Collecting locally available allied species of vegetable crops
3. Preparing herbarium and specimens

**THEORY**

**UNIT-I:** *Significance of systematics-* Significance of systematics and crop diversity in vegetable crops; Principles of classification; different methods of classification; Salient features of international code of nomenclature of vegetable crops

**UNIT-II:** *Origin and evolution-* Origin, history, evolution and distribution of vegetable crops

**UNIT-III:** *Botanical and morphological description-* Botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables; Morphological keys to identify important families, floral biology, floral formula and diagram; Morphological description of all parts of vegetables

**UNIT-IV:** *Cytology*- Cytological level of various vegetable crops with descriptive keys

**UNIT-V:** *Molecular markers*- Importance of molecular markers in evolution of vegetable crops; Molecular markers as an aid in characterization and taxonomy of vegetable crops

**PRACTICAL**

1. Identification, description, classification and maintenance of vegetable species and varieties;
2. Survey, collection of allied species and genera locally available;
3. Preparation of keys to the species and varieties;
4. Methods of preparation of herbarium and specimens.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedures
- Group discussion

**SUGGESTED READINGS**

1. Chopra, G.L. 1968. *Angiosperms- systematics and life cycle*. S. Nagin
2. Dutta, A.C. 1986. *A class book of botany*. Oxford Univ. Press.
3. Pandey, B.P. 1999. *Taxonomy of angiosperm*. S. Chand and Co
4. Peter, K.V. and Pradeep Kumar, T. 2008. *Genetics and breeding of vegetables*. ICAR.
5. Peter, K.V. and Hazra, P. (Eds) 2012. *Handbook of vegetable*s. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
6. Peter, K.V. and Hazra, P. (Eds) 2015. *Handbook of vegetables* Volume II. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
7. Peter, K.V. and Hazra, P. (Eds) 2015. *Handbook of vegetables* Volume III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
8. Simmonds, N.W. and Smartt, J. 1995. *Evolution of crop plants*. Wiley-Blackwell.
9. Soule, J. 1985. *Glossary for Horticultural Crops*. John Wiley and Sons.
10. Srivastava, U., Mahajan, R.K., Gangopadyay, K.K., Singh, M. and Dhillon, B.S. 2001. *Minimal descriptors of agri-horticultural crops. Part-II: Vegetable Crops*. NBPGR, New Delhi.
11. Vasistha, 1998. *Taxonomy of angiosperm*. Kalyani Publ.
12. Vincent, E.R. and Yamaguchi, M. 1997. *World vegetables*. 2nd Ed. Chapman and Hall.

## VSC 527 ORGANIC VEGETABLE PRODUCTION 2(1+1)

**WHY THIS COURSE?**

Organic vegetable farming is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. Organic farming has been simply defined as a production system working in partnership with nature to produce vegetable crops. The current trend towards increasing popularity of organically produced vegetables is relatively new. The objective of organic farming is to produce safer food and to keep the environment healthy. During the decade of nineties, the interest in organic farming began to creep into the mainstream consumer purchases. Currently, it appears to be an influx of business oriented producers into the organic production field. The increasing popularity of organic food among the elite societies is due to the belief that food produced with this system is free of pesticides and has greater nutritive value than conventionally produced food. The students of vegetable science need to have an understanding of organic vegetable farming technology.

**AIM OF THIS COURSE**

To elucidate principles, concepts and their applications in organic farming of vegetable crops
The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Organic vegetable production | 1. Importance and principles |

| | | |
|---|---|---|
| | | 2. Organic production of vegetables |
| | | 3. Managing soil fertility |
| | | 4. Composting methods |
| | | 5. Certification and export |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:
1. Appreciate the scope and scenario of organic vegetable production in India
2. Acquire knowledge about the organic vegetable production technology
3. Adopting production of organic vegetable crops a s entrepreneur

**THEORY**

**UNIT-I:** *Importance and principles*- Importance, principles, perspective, concepts and components of organic farming in vegetable crops

**UNIT-II:** *Organic production of vegetables*- Organic production of vegetable crops viz., Solanaceous, Cucurbitaceous, Cole, root and tuber crops

**UNIT-III***: Managing soil fertility*- Managing soil fertility, mulching, raising green manure crops, weed management in organic farming system; Crop rotation in organic production; Processing and quality control of organic vegetable produce

**UNIT-IV:** *Composting methods*- Indigenous methods of composting, Panchyagavvya, Biodynamics preparations and their application; ITKs in organic vegetable farming; Role of botanicals and bio-control agents in the management of pests and diseases in vegetable crops

**UNIT-V:** *Certification and export*- Techniques of natural vegetable farming, GAP and GMP certification of organic products; Export- opportunity and challenges

**PRACTICAL**

1. Methods of preparation and use of compost, vermicompost, biofertilizers and biopesticides;
2. Soil solarisation; Use of green manures;
3. Waste management; Organic soil amendments in organic production of vegetable crops;
4. Weed, pest and disease management in organic vegetable production;
5. Visit to organic fields and marketing centres.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedures
- Group discussion

**SUGGESTED READINGS**

1. Dahama, A.K. 2005. *Organic farming for sustainable agriculture*. 2nd Ed. Agrobios.
2. Gehlot, G. 2005. *Organic farming; standards, accreditation certification and inspection*. Agrobios.
3. Palaniappan, S.P. and Annadorai, K. 2003. *Organic farming, theory and practice*. Scientific publ.
4. Pradeep Kumar, T., Suma, B., Jyothi Bhaskar and Satheesan, K.N. 2008. *Management of horticultural crops.* New India Publ. Agency.
5. Shivashankar, K. 1997. *Food security in harmony with nat*ure. 3rd IFOAMASIA, Scientific Conf.1-4 Dec., UAS, Bangalore.

| VSC 528 | PRODUCTION OF SPICE CROPS | 3(2+1) |
|---|---|---|

**WHY THIS COURSE?**

Spices are an important part of human history and played an important role in the development of most cultures around the world. Spice may be a seed, fruit, root, bark, or any other plant substance primarily used for flavouring, colouring, or preserving food. Spices are distinguished from herbs, which are the leaves, flowers, or stems of plants used for flavouring or as a garnish. Many spices have antimicrobial properties, because of which why spices are more commonly used in warmer climates, which have more infectious diseases, and use of spices is prominent in meat, which is predominantly susceptible to spoiling. The students of vegetable science need to have an understanding of production technology of spices and their processing before supplying them to the market or further use.

**AIM OF THIS COURSE**

To impart basic knowledge about the importance and production technology of spices grown in India.

The course is constructed given as under:

| S. No. | Block | Units |
|---|---|---|
| 1. | Production of spice crops | 1. Fruit spices |
| | | 2. Bud and kernel spices |
| | | 3. Underground spice crops |
| | | 4. Seed spices |
| | | 5. Tree spices |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:

1. Appreciate the scope and scenario of production of spice crops in India
2. Acquire knowledge about the production technology and processing of spice crops
3. Adopting production of spice crops as entrepreneur

**THEORY**

Introduction and importance of spice crops- historical accent, present status (national and international), future prospects, botany and taxonomy, climatic and soil requirement, commercial cultivars/hybrids, site selection, layout, sowing/planting time and methods, seed rate and seed treatment, nutritional and irrigation requirement, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, postharvest management, plant protection measures, quality control and pharmaceutical significance of crops mentioned below:

**UNIT-I:** *Fruit spices*- Black pepper, small cardamom, large cardamom and allspice

**UNIT-II:** *Bud and kernel*- Clove and nutmeg

**UNIT-III:** *Underground spices*- Turmeric, ginger and garlic

**UNIT-IV:** *Seed spices*- Coriander, fenugreek, cumin, fennel, ajowain, dill and celery

**UNIT-V:** *Tree spices*- Cinnamon, tamarind, garcinia and vanilla

**PRACTICAL**

1. Identification of seeds and plants;
2. Botanical description of plant;
3. Preparation of spice herbarium;
4. Propagation;
5. Nursery raising;
6. Field layout and method of planting;
7. Cultural practices;
8. Harvesting, drying, storage, packaging and processing;
9. Value addition;
10. Short term experiments on spice crops.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedures
- Group discussion

**SUGGESTED READINGS**

1. Agarwal, S., Sastry, E.V.D. and Sharma, R.K. 2001. S*eed spices: production, quality, export.* Pointer Pub.
2. Arya, P.S. 2003. *Spice crops of India*. Kalyani.
3. Bhattacharjee, S.K. 2000. *Handbook of aromatic plants*. Pointer publications.
4. Bose, T.K., Mitra, S.K., Farooqi, S.K. and Sadhu, M.K. (Eds.). 1999. *Tropical horticulture*. Vol**.I**. Naya Prokash.
5. Chadha, K.L. and Rethinam, P. (Eds.) 1993. *Advances in horticulture*. Vols. IX-X. Plantation crops and spices. Malhotra Publ. House.
6. Gupta, S. (Ed.). *Handbook of spices and packaging with formulae*. Engineers India research institute, Delhi.
7. Kumar, N.A., Khader, P., Rangaswami and Irulappan, I. 2000. *Introduction to spices, plantation crops, medicinal and aromatic plants*. Oxford and IBH.
8. Nybe, E.V., Miniraj, N. and Peter, K.V. 2007. *Spices*. New India Publ. Agency.
9. Parthasarthy, V.A., Kandiannan ,V. and Srinivasan, V. ś2008. *Organic spices*. NIPA.
10. Peter, K.V. 2001. *Handbook of herbs and spices*. Vols. I-III. Woodhead P. Co. UK and CRC USA
11. Pruthi, J.S. (Ed.) 1998. *Spices and condiments*. National Book Trust
12. Pruthi, J.S. 2001. *Minor spices and condiments- crop management and post-harvest technology*. ICAR.
13. Purseglove, J.W., Brown, E.G., Green, C.L. and Robbins, S.R.J. (Eds.) 1981. *Spices*. Vols. I, II. Longman.
14. Shanmugavelu, K.G., Kumar, N. and Peter, K.V. 2002. *Production technology of spices and plantation crops*. Agrobios.
15. Thamburaj, S. and Singh, N. (Eds.) 2004. *Vegetables, tuber crops and spices*. ICAR.
16. Tiwari, R.S. and Agarwal, A. 2004. *Production technology of spices*. IBDC.
17. Varmudy, V. 2001. *Marketing of spices*. Daya Publ. House.


## VSC 531 POSTHARVEST MANAGEMENT OF VEGETABLE CROPS 3(2+1)

**WHY THIS COURSE?**

Vegetables are highly perishable crops as they have great quantity and quality loss after harvest. Hence, they require integrated approach to arrest their spoilage, which causes tonnes of vegetable produce annually. Lack of postharvest awareness and inadequacy of equipments are the major problems in postharvest chain, which lead to a serious post-harvest loss in the developing countries every year. A comprehensive understanding of postharvest factors causing deterioration is necessary to overcome these challenges. Pre and postharvest management such as use of improved varieties, good cultural practices, good pre and postharvest handling practices, management of temperature, relative humidity and storage atmosphere according to crop requirement, use of permitted chemicals, design of appropriate packaging material and storage structures are some of the control measures used in reducing postharvest losses, therefore, this course was customized.

**AIM OF THE COURSE**

To facilitate deeper understanding of principles and to acquaint the student with proper handling and management technologies of vegetable crops for minimizing the post-harvest losses.
The course is organized as follows:

| S.No. | Block | Units |
|---|---|---|
| 1. | Post-harvest management of vegetable crops | 1. Importance and scope |
| | | 2. Maturity indices and biochemistry |
| | | 3. Harvesting and losses factors |
| | | 4. Packinghouse operations |
| | | 5. Methods of storage |

**COURSE OUTCOMES:**

After successful completion of this course, the students are expected to be able to understand:
1. Regulation of postharvest losses by using chemicals and growth regulators.
2. Pre and postharvest treatments for extending shelf life of vegetable crops.
3. Packinghouse operations for extending the shelf life of vegetable crops.

4. Successful storage of vegetable crops.

**THEORY**

**UNIT-I:** *Importance and scope*- Importance and scope of post-harvest management of vegetables.

**UNIT-II:** *Maturity indices and biochemistry*- Maturity indices and standards for different vegetables; Methods of maturity determination; Biochemistry of maturity and ripening; Enzymatic and textural changes; Ethylene evolution and ethylene management; Respiration and transpiration along with their regulation methods.

**UNIT-III:** *Harvesting and losses factors*- Harvesting tools and practices for specific market requirement; Postharvest physical and biochemical changes; Preharvest practices and other factors affecting postharvest losses.

**UNIT-IV:** *Packinghouse operations*- Packing house operations; Commodity pre-treatments chemicals, wax coating, precooling and irradiation; Packaging of vegetables, prevention from infestation, management of postharvest diseases and principles of transportation.

**UNIT-V:** *Methods of storage*- Ventilated, refrigerated, modified atmosphere and controlled atmosphere storage, hypobaric storage and cold storage; Zero-energy cool chamber, storage disorders like chilling injury in vegetables.

**PRACTICAL**

1. Studies on stages and maturing indices;
2. Ripening of commercially important vegetable crops;
3. Studies of harvesting, pre-cooling, pre-treatments, physiological disorders- chilling injury;
4. Improved packaging;
5. Use of chemicals for ripening and enhancing shelf life of vegetables;
6. Physiological loss in weight, estimation of transpiration, respiration rate and ethylene release;
7. Storage of important vegetables;
8. Cold chain management;
9. Visit to commercial packinghouse, cold storage and control atmosphere storage.

**TEACHING METHODS/ACTIVITIES**

- Classroom lectures including ppt.
- Students group discussion
- Individual or group assignments (writing and speaking)
- Presentation of practical handwork

**SUGGESTED READINGS**


1. Chadha, K.L. and Pareek, O.P. 1996. *Advances in horticulture*. Vol. IV. Malhotra Publ. House.
2. Chattopadhyay, S.K. 2007. *Handling, transportation and storage of fruit and vegetables*. Gene-Tech books, New Delhi.
3. Haid, N.F. and Salunkhe, S.K. 1997. *Postharvest physiology and handling of fruits and vegetables*. Grenada Publ.
4. Mitra, S.K. 1997. *Postharvest physiology and storage of tropical and sub-tropical fruits*. CABI.
5. Paliyath G., Murr D.P., Handa, A.K. and Lurie, S. 2008. *Postharvest biology and technology of Fruits, vegetables and flowers*. Wiley-Blackwell, ISBN: 9780813804088.
6. Ranganna, S. 1997. *Handbook of analysis and quality control for fruit and vegetable Products*. Tata McGraw-Hill.
7. Stawley, J. K. 1998. *Postharvest physiology of perishable plant products*. CBS publishers.
8. Sudheer, K.P. and Indira, V. 2007. *Postharvest technology of horticultural crops*. NIPA.
9. Thompson, A.K. (Ed.) 2014. *Fruit and vegetables: harvesting, handling and storage* (Vol. 1 and 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.
10. Verma, L.R. and Joshi, V.K. 2000. *Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management*. Indus Pub. Co., New Delhi. ISBN 8173871086.
11. Willis, R, McGlassen, W.B., Graham, D. and Joyce, D. 1998. *Postharvest: An introduction to the physiology and handling of fruits, vegetables and ornamentals*. CABI.
12. Wills, R.B.H. and Golding, J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables.* CABI Publishing, ISBN 9781786391483.

13. Wills, R.B.H. and Golding, J. 2017. *Advances in postharvest fruit and vegetable technology*. CRC Press, ISBN 9781138894051.

## VSC 532 PRODUCTION OF UNDERUTILIZED VEGETABLE CROPS 3(2+1)

**WHY THIS COURSE?**

With increasing population and fast depletion of natural resources, it has become essential to explore the possibilities of using newer indigenous plant resources. Underutilized crops are plant species that are used traditionally by the country people for their food, fibre, fodder, oil, or medicinal properties but have yet to be adopted by large scale agriculturalists. In general, underutilized plants constitute those plant species that occur as life support species in extreme environmental conditions and threatened habitats, having genetic tolerance to survive under harsh conditions and possess qualities of nutritional and/or industrial importance for a variety of purposes. Underutilized crops are those plant species with under-exploited potential for contributing to food security, health (nutritional or medicinal), income generation and environmental services. Once the underutilized food crops are properly utilized, they may help to contribute in food security, nutrition, health, income generation and environmental services. The underutilized crops can be defined as the crops, which being region specific are less available, less utilized or rarely used. These underutilized crop species have also been described as *rare, minor, orphan, promising* and *little-used* vegetable crops. The students of vegetable science need to have an understanding of production technology of underutilized vegetable crops.

**AIM OF THIS COURSE**

To impart knowledge about production technology of lesser utilized vegetable crops.
The course is constructed given as under:

| S. No. | Block | Units |
|---|---|---|
| 1. | Production of underutilized vegetable crops | 1. Stem and bulb crops |
| | | 2. Cole and salad crops |
| | | 3. Gourds and melons |
| | | 4. Leafy vegetables |
| | | 5. Yams and beans |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:
1. Appreciate the scope and scenario of production of underutilized vegetable crops in India.
2. Acquire knowledge about the production technology of underutilized vegetable crops.
3. Adopting production of lesser utilised crops as entrepreneur.

**THEORY**

Importance and scope, botany and taxonomy, climate and soil requirement, commercial varieties/hybrids, improved cultural practices, physiological disorders, harvesting and yield, plant protection measures and post-harvest management of:

**UNIT-I:** *Stem and bulb crops*- Asparagus, leek and Chinese chive.

**UNIT-II:** *Cole and salad crops*- Red cabbage, Chinese cabbage, kale, sweet corn and baby corn.

**UNIT-IV:** *Gourds and melons*- Sweet gourd, spine gourd, teasle gourd, round gourd, and little/Ivy gourd, snake gourd, pointed gourd, kachri, long melon, snap melon and gherkin.

**UNIT-III:** *Leafy vegetables*- Celery, parsley, Indian spinach (poi), spinach, chenopods, chekurmanis and indigenous vegetables of regional importance.

**UNIT-V:** *Yam and beans*- Elephant foot yam, yam, yam bean, lima bean and winged bean.

**PRACTICAL**

1. Identification and botanical description of plants and varieties;
2. Seed/planting material;
3. Production, lay out and method of planting;
4. Important cultural operations;
5. Identification of important pests and diseases and their control;

6. Maturity standards and harvesting;
7. Visit to local farms.

**TEACHING METHODS/ACTIVITIES**

- Delivering of lectures by power point presentation.
- Assignment (written and speaking).
- Student presentation.
- Hands on training of different procedures.
- Group discussion.

**SUGGESTED READINGS**


1. Bhat, K.L. 2001. *Minor vegetables-untapped potential*. Kalyani publishers, New Delhi.
2. Indira, P. and Peter, K.V. 1984. *Unexploited tropical vegetables*. Kerala Ag. University, Kerala.
3. Pandey, A.K. 2011. *Aquatic vegetables*. Agrotech publisher academy, New Delhi.
4. Peter, K.V. (Eds.) 2007-08. *Underutilized and underexploited horticultural crops*. Vol.1-4, NIPA, Lucknow.
5. Peter, K.V. and Hazra, P. (Eds) 2012. *Handbook of vegetables*. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
6. Peter, K.V. and Hazra, P. (Eds) 2015. *Handbook of vegetables* Volume II and III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
7. Rana, M.K., 2018. *Vegetable crop science*. CRC Press Taylor and Francis Group 6000 Broken Sound Parkway NW, Suite 300 Boca Raton, FL 33487-2742 ISBN: 978-1- 1380-3521-8
8. Rubatzky, V.E. and Yamaguchi, M. 1997. *World vegetables: vegetable crops*. NBPGR, New Delhi.


## VSC 533 PROCESSING OF VEGETABLE CROPS 2(1+1)

**WHY THIS COURSE?**

In India, agriculture is the basis of economy. Agricultural industries and related activities, which can be termed as agriculturally based vegetable processing, can account for a considerable proportion of their output. Both established and planned vegetable processing projects aim at solving a very clearly identified developmental problems. The growers sustain substantial losses due to insufficient demand in the market, weak infrastructure, poor transportation and perishable nature of the vegetable crops. During the postharvest glut, the loss is considerable and often some of the produce are fed to the animals or allowed to decay. Even the established vegetable canning industries or small/medium scale processing centres suffer huge loss due to erratic supplies since the growers like to sell their produce in the open market directly to the consumers, or the produce may not be of enough high quality to process but it might be good enough for the table use, meaning that processing is seriously underexploited. The main objective of vegetable processing is to supply wholesome, safe, nutritious and acceptable food to the consumers throughout the year. Vegetable processing also aims to replace imported products like squash, jams, tomato sauces, pickles, *etc.*, besides earning foreign exchange by exporting finished or semi-processed products. The students of vegetable science need to have an understanding of vegetable processing.

**AIM OF THIS COURSE**

To educate the students about the principles and practices of processing in vegetable crops
The course is constructed given as under:

| S. No. | Block | Units |
|---|---|---|
| 1. | Processing of vegetable crops | 1. Present status |
| | | 2. Spoilage and biochemical changes |
| | | 3. Processing equipments |
| | | 4. Quality control |
| | | 5. Value addition |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:
1. Appreciate the scope and scenario of vegetable processing in India
2. Acquire knowledge about the processing technology of vegetable crops

3. Adopting processing products of vegetable crops at small or medium scale
4. Adopt processing of vegetable crops as entrepreneur

**THEORY**

**UNIT-I:** *Present status*- Present status and future prospects of vegetable preservation industry in India

**UNIT-II:** *Spoilage and biochemical changes*- Spoilage of fresh and processed vegetable produce; biochemical changes and enzymes associated with spoilage of vegetable produce; Principal spoilage organisms, food poisoning and their control measures; Role of microorganisms in food preservation

**UNIT-III:** *Processing equipments*- Raw material for processing; Primary and minimal processing; Processing equipments; Layout and establishment of processing industry; FPO licence; Importance of hygiene; Plant sanitation

**UNIT-IV:** *Quality control*- Quality assurance and quality control, TQM, GMP; Food standards- FPO, PFA, *etc*.; Food laws and regulations; Food safety- hazard analysis and critical control points (HACCP); Labeling and labeling act and nutrition labeling

**UNIT-V:** *Value addition*- Major value added vegetable products; Utilization of by-products of vegetable processing industry; Management of processing industry waste; Investment analysis; Principles and methods of sensory evaluation of fresh and processed vegetables

**PRACTICAL**

1. Study of machinery and equipments used in processing of vegetable produce;
2. Chemical analysis for nutritive value of fresh and processed vegetable;
3. Study of different types of spoilage in fresh as well as processed vegetable produce;
4. Classification and identification of spoilage organisms;
5. Study of biochemical changes and enzymes associated with spoilage;
6. Laboratory examination of vegetable products;
7. Sensory evaluation of fresh and processed vegetables;
8. Study of food standards- National, international, CODEX Alimentarius;
9. Visit to processing units to study the layout, hygiene, sanitation and waste management.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures.
- Assignment (written and speaking).
- Student presentation.
- Hands on training of different procedures.
- Group discussion.

**SUGGESTED READINGS**


1. Arthey, D. and Dennis, C. 1996. *Vegetable processing*. Blackie/Springer-Verlag.
2. Chadha, D.S. 2006. *The Prevention of food adulteration act*. Confed. of Indian Industry.
3. Desrosier, N.W. 1977. *Elements and technology*. AVI Publ. Co.
4. FAO. 1997. *Fruit and Vegetable processing*. FAO.
5. FAO. *CODEX Alimentarius: Joint FAO/WHO food standards programme*. 2nd Ed. Vol. VB. *tropical fresh fruits and vegetables*. FAO.
6. FAO. *Food quality and safety systems- training manual on food hygiene and haccp*. FAO.
7. Fellow's, P. 1988. *Food processing technology*. Ellis Horwood International.
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9. Giridharilal, G.S., Siddappa and Tandon, G.L. 1986. *Preservation of fruits and vegetables*. ICAR.
10. Gisela, J. 1985. *Sensory evaluation of food- theory and practices*. Ellis Horwood.
11. Graham, H.D. 1980. *Safety of foods*. AVI Publ. Co.
12. Hildegrade, H. and Lawless, H.T. 1997. *Sensory evaluation of food*. CBS.
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14. Mahindru, S.N. 2004. *Food safety: concepts and reality*. APH Publ. Corp.
15. Ranganna, S. 1986. *Handbook of analysis and quality control for fruit and vegetable products*. 2nd Ed. Tata-McGraw Hill.
16. Shapiro, R. 1995. *Nutrition labeling handbook*. Marcel Dekker.

17. Srivastava, R.P. and Kumar, S. 2003. *Fruit and vegetable preservation: principles and practices*. 3rd Ed. International Book Distri. Co.
18. Tressler and Joslyn, M.A. 1971. *Fruit and vegetable juice processing technology*. AVI Publ. Co.
19. Verma, L.R. and Joshi, V.K. 2000. *Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management*. Indus Publ. Co.

# COURSE CONTENTS: Ph.D. VEGETABLE SCIENCE

## VSC 611 RECENT TRENDS IN VEGETABLE PRODUCTION 3(3+0)

**WHY THE COURSE?**

India is the second largest producer of vegetables in the world, next only to China. Most challenging task is to ensure for continuous and enough supply of vegetables to growing population. Urban areas are experiencing substantial increase in population; this growth is accompanied with change in food habits and rising concerns for food quality. Here, food quality refers to the optimum levels of the nutrition in the food along with the minimized amount of the chemical (pesticides/fertilizers) residues used in the production of the vegetables. Vegetables are being highly seasonal, perishable are also capital and labour intensive and need care in handling and transportation. Environmental stress (climate change) and shortage of water and land resources are major constraints haunting the production. Though the advances in science and information technology has resulted in more comfortable world with global linkages, these advances has led to changes in production practices. Thus, the students of vegetable science need to have an understanding of recent trends in production technology of vegetable crops and their management.

**AIM OF THE COURSE**

To keep abreast with latest developments and trends in production technology of vegetable crops.

The course is constructed given as under:

| S. No. | Block | Units |
|---|---|---|
| 1. | Recent trends in vegetable production | 1. Solanaceous crops |
| | | 2. Cole crops |
| | | 3. Okra, onion, peas and beans, amaranth and drumstick. |
| | | 4. Root crops and cucurbits |
| | | 5. Tuber crops |

**COURSE OUTCOMES**

After successful completion of this course, the students are exposed to:
1. Acquire the knowledge about recent trends in production technology of vegetable crops.

**THEORY**

Present status and prospects of vegetable cultivation; nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/disorders and correction methods; different cropping systems; mulching; Protected cultivation of vegetables, containerized culture for year round vegetable production; low cost polyhouse; nethouse production; crop modeling, organic gardening; vegetable production for pigments, export and processing of:

**UNIT-I:** *Solanaceous crops*: Tomato, brinjal, chilli, sweet pepper and potato.
**UNIT-II:** *Cole crops*: Cabbage, cauliflower and knol-khol, sprouting broccoli.
**UNIT-III:** Okra, onion, pea and beans, amaranth and drumstick.
**UNIT-IV:** *Root crops and cucurbits*: Carrot, beet root, turnip and radish and cucurbits
**UNIT-V:** *Tuber crops*: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures

- Assignment (written and speaking)
- Student presentation
- Group discussion

**SUGGESTED READINGS**

1. Bose, T.K. and Som, N.G. 1986. *Vegetable crops of India*. Naya prokash.
2. Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G. 2003. *Vegetable crops*. Vols. I-III. Naya Udyog.
3. Brewster, J.L. 1994. *Onions and other vegetable alliums*. CABI.
4. Chadha, K.L. and Kalloo, G. (Eds.) 1993. *Advances in horticulture.* Vols. V-X. Malhotra PH.
5. Chadha, K.L. (Ed.) 2002. *Handbook of horticulture*. ICAR.
6. Chauhan, D.V.S. (Ed.) 1986. *Vegetable production in India*. Ram prasad and Sons.
7. Fageria, M.S., Choudhary, B.R. and Dhaka, R.S. 2000. *Vegetable crops: production technology*. Vol. II. Kalyani.
8. FFTC. *Improved vegetable production in Asia*. Book Series No. 36.
9. Ghosh, S.P., Ramanujam, T., Jos, J.S., Moorthy, S.N. and Nair, R.G. 1988. *Tuber crops*. Oxford and IBH.
10. Gopalakrishanan, T.R. 2007. *Vegetable crops*. New India Publ. Agency.
11. Hazra, P. and Som, M.G. 2015. *Seed production and hybrid technology of vegetable crops*. Kalyani.
12. Hazra, P. 2016. *Vegetable science*. 2nd edn, Kalyani publishers, Ludhiana.
13. Hazra, P. 2019. *Vegetable production and technology*. New India publishing agency, New Delhi.
14. Kalloo, G. and Singh, K. (Ed.) 2001. *Emerging scenario in vegetable research and development*. Research periodicals and Book Publ. House.
15. Kurup, G.T., Palanisami, M.S., Potty, V.P., Padmaja, G., Kabeerathuma, S. and Pallai, S.V. 1996. *Tropical tuber crops, problems, prospects and future strategies*. Oxford and IBH.
16. Rana, M.K. 2008. *Olericulture in India*. Kalyani Publ.
17. Rana, M.K. 2008. *Scientific cultivation of vegetables*. Kalyani Publ.
18. Rubatzky, V.E. and Yamaguchi, M. (Eds.) 1997. *World vegetables: principles, production and nutritive values*. Chapman and Hall.
19. Saini, G.S. 2001. *A Text Book of oleri and flori culture*. Aman Publishing House.
20. Salunkhe, D.K. and Kadam, S.S. (Ed.) 1998. *Handbook of vegetable science and technology: production, composition, storage and processing*. Marcel Dekker.
21. Shanmugavelu, K.G. 1989. *Production technology of vegetable crops*. Oxford and IBH.
22. Sin, M.T. and Onwueme, I.C. 1978. *The tropical tuber crops*. John Wiley and Sons.
23. Singh, D.K. 2007. *Modern vegetable varieties and production technology*. IBDC
24. Singh, N.P., Bhardwaj, A.K., Kumar, A. and Singh, K.M. 2004. Modern technology on Vegetable *production*. International book distr. Co.
25. Singh, P.K., Dasgupta, S.K. and Tripathi, S.K. 2006. *Hybrid vegetable development*. IBDC.
26. Singh, S.P. (Ed.) 1989. *Production technology of vegetable crops*. Agril. Comm. Res. Centre.
27. Thamburaj, S. and Singh, N. (Eds.). 2004. *Vegetables, tuber crops and spices*. ICAR.
28. Thompson, H.C. and Kelly, W.C. (Eds.). 1978. *Vegetable crops*. Tata McGraw-Hill.

## VSC 612 ADVANCES IN BREEDING OF VEGETABLE CROPS 3(3+0)

**WHY THE COURSE?**

The improvement of vegetable crops has until recently, been largely confined to conventional breeding approaches and such programmes rely on hybridization of plants which have desirable heritable characteristics and on naturally or artificially induced random mutations. The introduction of new genetic information can result in increased resistance to insect pest, diseases tolerance to environmental condition, improved quality *etc*. The modern biotechnological tools like molecular assisted selection, double haploidy, genetic engineering *etc*. can be of immense importance for rapid development of superior varieties with desirable qualitative and quantitative traits. Therefore, conventional breeding in conjunction with molecular biology has bright prospects of developing high yielding vegetable varieties with high nutraceuticals and bio active compounds suitable for fresh as well as processed market. The students of vegetable science who are having breeding as major subject need to have an understanding of recent technologies in vegetable crops.

**AIM OF THE COURSE**

To impart knowledge on the recent research trends and advances in breeding of vegetable crops.

The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Advances in Breeding of vegetable crops | 1. Solanaceous crops and okra |
| | | 2. Cucurbits and Cole crops |
| | | 3. Legumes and leafy vegetables |
| | | 4. Root crops and onion |
| | | 5. Tuber crops |

**COURSE OUTCOMES**

After successful completion of this course, the students are exposed to:

1. Breeding objectives and trends.
2. Recent Advances in vegetable breeding.

**THEORY**

Evolution, distribution, cytogenetics, Genetics and genetic resources, wild relatives, genetic divergence, hybridization, inheritance of qualitative and quantitative traits, heterosis breeding, plant idotype concept and selection indices, breeding mechanisms, pre breeding, mutation breeding, ploidy breeding, breeding for biotic and abiotic stresses, breeding techniques for improving quality and processing characters, bio-fortification, in – vitro breeding, marker assisted breeding, haploidy, development of transgenic.

**UNIT-I:** *Solanaceous crops* (Tomato, Brinjal, Hot Pepper, Sweet Pepper, Potato) and Okra

**UNIT-II:** *Cucurbits and Cole crops*- Muskmelon, watermelon, bottle gourd, bitter gourd, round gourd, ridge gourd, pumpkin and cucumber, cauliflower, cabbage and knol-khol.

**UNIT-III:** *Legumes and leafy vegetables* - Pea and Beans, Amaranth, Palak, Chenopods and Lettuce.

**UNIT-IV:** *Root crops and onion* - Carrot, Beetroot, Radish, Turnip, Onion

**UNIT-V:** *Tuber crops* - Sweet potato, Tapioca, Elephant foot yam, *Colocasia*, *Dioscorea*

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Group discussion

**SUGGESTED READINGS**


1. Allard, R.W. 1999. *Principle of plant breeding.* John Willey and Sons, USA.
2. Basset, M.J. (Ed.). 1986. *Breeding vegetable crops.* AVI Publ.
3. Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J. 2005. *Plant genetic resources: horticultural crops.* Narosa Publ. House.
4. Fageria, M.S., Arya, P.S. and Choudhary, A.K. 2000. *Vegetable crops: Breeding and seed production.* Vol. I. Kalyani.
5. Gardner, E.J. 1975. *Principles of genetics.* John Wiley and Sons.
6. Hayes, H.K., Immer, F.R. and Smith, D.C. 1955. *Methods of plant breeding.* McGraw-Hill.
7. Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.). 1993. *Plant Breeding-principles and prospects.* Chapman and Hall.
8. Hazra, P. and Som, M.G. 2015. *Vegetable science* (2$^{nd}$ ed.), Kalyani pub., Ludhiana, 598 p
9. Hazra, P. and Som, M.G. 2016. *Vegetable seed production and hybrid technology* (2$^{nd}$ ed), Kalyani Publishers, Ludhiana, 459 p
10. Kalloo, G. 1988. *Vegetable breeding.* Vols. I-III. CRC Press.
11. Kalloo, G. 1998. *Vegetable breeding.* Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
12. Kumar, J.C. and Dhaliwal, M.S. 1990. *Techniques of developing hybrids in vegetable crops.* Agro BP.

13. Paroda, R.S. and Kalloo, G. (Eds.) 1995. *Vegetable research with special reference to hybrid technology in Asia-Pacific Region*. FAO.
14. Peter, K.V. and Pradeep Kumar, T. 2008. *Genetics and breeding of vegetables*. ICAR.
15. Peter, K.V. and Hazra, P. (Eds) 2012. *Handbook of vegetables*. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
16. Peter, K.V. and Hazra, P. (Eds) 2015. *Handbook of vegetables* Volume II. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
17. Peter, K.V. and Hazra, P. (Eds) 2015. *Handbook of vegetables* Volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
18. Rai, N. and Rai, M. 2006. *Heterosis breeding in vegetable crops*. New India Publ. Agency.
19. Ram, H.H. 1998. *Vegetable breeding: principles and practices*. Kalyani Publ.
20. Simmonds, N.W. 1978. *Principles of crop improvement*. Longman.
21. Singh BD. 1983. *Plant Breeding*. Kalyani Publ.
22. Singh, P.K., Dasgupta, S.K. and Tripathi, S.K. 2004. *Hybrid vegetable development*. IBDC
23. Swarup, V. 1976. *Breeding procedure for cross-pollinated vegetable crops*. ICAR.

## VSC 621 ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS 3(2+1)

**WHY THE COURSE?**

Improvement of vegetable crops has traditionally focused on enhancing a plant's ability to resist diseases or insects. That is evidenced by the large number of disease- or insect resistant cultivars or germplasm released and used. Research on crop resistance or tolerance to abiotic stresses (heat, cold, drought, flood, salt, pH, *etc.*) has not received much attention. However, that is changing as a result of the research and publicity of global warming. The changing environments pose serious and imminent threats to vegetable production and place unprecedented pressures on the sustainability of vegetable production. The challenges and opportunities coexist for our dynamic and resilient industry. In addition to conserving resources, we should mitigate abiotic stresses and adapt to the warming planet. The student of vegetable science need to know the different methods involved to mitigate the abiotic stress in vegetable crops.

**AIM OF THE COURSE**

To update knowledge on the recent research trends in the field of abiotic stress management in vegetables. To teach management practices to mitigate abiotic stress in vegetable crops
The course is constructed given as under:

| S.No. | Block | Units |
|---|---|---|
| 1. | Abiotic stress management in vegetable crops | 1. Environmental stress |
| | | 2. Mechanism and measurements of tolerance |
| | | 3. Soil-plant-water relations |
| | | 4. Techniques of vegetable growing under high stress condition |
| | | 5. Use of chemicals |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:
1. Acquire the knowledge about effect of different abiotic stresses on vegetables
2. Methods to mitigate abiotic stress in vegetables

**THEORY**

**Block 1: Abiotic stress management in vegetable crops**

**UNIT-I:** *Environmental stress* - its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.

**UNIT-II:** *Mechanism and measurements* - tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

**UNIT-III:** *Soil-plant-water relations* - under different stress conditions in vegetable crops production and their management practices.

**UNIT-IV:** Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

**UNIT-V:** Use of chemicals - techniques of vegetable growing under high and low temperature conditions, use of chemicals and antitranspirants in alleviation of different stresses.

**PRACTICAL**

1. Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops;
2. Measurement of tolerance to various stresses in vegetable crops;
3. Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions;
4. Use of chemicals for alleviation of different stresses.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedure
- Group discussion

**SUGGESTED READINGS**

1. Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J. 2005. *Plant genetic resources: horticultural crops*. Narosa Publ. House.
2. Dwivedi, P. and Dwivedi, R.S. 2005. *Physiology of abiotic stress in plants*. Agrobios.
3. Janick, J.J. 1986. *Horticultural science*. 4th Ed. WH Freeman and Co.
4. Kaloo, G. and Singh, K. 2001. *Emerging scenario in vegetable research and development*. Research periodicals and book publ. house.
5. Kaloo, G. 1994. *Vegetable breeding*. Vols. I-III. Vedams eBooks.
6. Lerner, H.R. (Eds.) 1999. *Plant responses to environmental stresses*. Marcel Decker.
7. Maloo, S.R. 2003. *Abiotic stresses and crop productivity*. Agrotech Publ. Academy.
8. Narendra, T. *et al.* 2012. *Improving crops resistance to abiotic stress*. Wiley and Sons.US.
9. Peter, K.V. and Pradeep Kumar, T. 2008. *Genetics and breeding of vegetables*. ICAR.
10. Peter, K.V. and Hazra, P. (Eds) 2015. *Handbook of vegetables volume* II. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
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12. Ram, H.H. 2001. *Vegetable breeding*. Kalyani.
13. Rao, N.K. (Eds.) 2016. *Abiotic stress physiology of horticultural crops*. Springer publication.

## VSC 622 SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE SEEDS 3(2+1)

**WHY THE COURSE?**

Every farmer should able to access healthy seeds which are genetically pure, with high seed vigour and good germination percentage. Timely availability of good quality seeds at reasonable price ensures good yield and profit to the farmers. The seeds plays a vital role in agriculture and acts as a carrier of the genetic potential of varieties. Quality seed production which follows efficient certification procedures plays a major role in the increase of food production of our country. To ensure this, the Government has prescribed standards and has brought in seed production techniques, testing, certification and marketing procedures through the Seeds Act, 1966. In the current scenario, the demand for good quality certified seeds far exceed the availability in the market. This manual provides details about production and procurement of good quality seeds.

**AIM OF THE COURSE**

To impart the knowledge on seed certification, processing and storage of vegetable seeds Learning outcomes

After successful completion of this course, the students are expected to:

1. Acquire the knowledge on seed certification
2. Acquire the knowledge on seed processing and storage

**THEORY**

**Block 1: Seed Certification, Processing and Storage of Vegetable Seeds.**

**UNIT-I:** Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian Minimum seed Certification standards, Planning and management of seed certification programmes.

**UNIT-II:** Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification Schemes.

**UNIT-III:** Principles of seed processing, Methods of seed drying and cleaning, seed processing plant- Layout and design, seed treatment, seed quality enhancement, packaging and marketing.

**UNIT-IV:** Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open, bulk, controlled, germplasm, cryopreservation), factors affecting seed longevity in storage (Pre and post-harvest factors).

**UNIT-V:** Seed aging and deterioration, maintenance of seed viability and vigour during storage, storage methods, storage structures, transportation and marketing of seeds.

**PRACTICAL**

1. General procedures of seed certification;
2. Field inspection and standards;
3. Isolation and rouging;
4. Inspection and sampling at harvesting, threshing and processing;
5. Testing physical purity, germination and moisture, grow-out test;
6. Visit to regulatory seed testing and plant quarantine laboratories;
7. Seed processing plants and commercial seed stores.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation individual or in group
- Hands on training of different procedure
- Group discussion

**SUGGESTED READINGS**


1. Agarwaal, P. K. and Anuradha, V. 2018. *Fundamentals of seed science and technology*. Brilliant publications, New Delhi.
2. Basra, A.S. 2000. *Hybrid seed production in vegetables*. CRC press, Florida, USA.
3. Bench, A.L.R. and Sanchez, R.A. 2004. *Handbook of seed physiology*. Food products press, NY/ London.
4. Chakraborty, S. K., Prakash, S., Sharma, S.P. and Dadlani, M. 2002. *Testing of distinctiveness, uniformity and stability for plant variety protection*. IARI, New Delhi
5. Copland, L.O. and McDonald, M.B. 2004. *Seed science and technology*. Kluwer academic press.
6. Fageria, M.S., Arya, P.S. and Choudhry, A.K. 2000. *Vegetable crops: breeding and seed production* Vol 1. Kalyani publishers, New Delhi.
7. George, R.A.T. 1999. *Vegetable seed production* (2nd Edition). CAB International.
8. Hazra, P. and Som, M.G. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani publishers, Ludhiana, 459 p
9. Kalloo, G., Jain, S.K., Vari, A.K. and Srivastava, U. 2006. *Seed: A global perspective*. Associated publishing company, New Delhi.
10. Singhal, N.C. 2003. *Hybrid seed production*. Kalyani publishers, New Delhi.


## VSC 623 BREEDING FOR SPECIAL TRAITS IN VEGETABLE CROPS 2(2+0)

**WHY THE COURSE?**

Many epidemiological studies reveal that people having a high level of consumption of vegetables presents a better health and lower risk of chronic diseases, including cardiovascular diseases and different types of cancer. Vegetables contain many bioactive compounds and represent a major source of antioxidants and other compounds that are beneficial to human health. Consumers are increasingly demanding vegetables with bioactive properties that contribute to maintaining a good health and preventing diseases. In consequence, breeding programmes in vegetables are increasingly considering the content in bioactive compounds as a major breeding objective. In this way, there is an increasing number of breeding programmes and scientific studied aimed at improving the content in bioactive compounds of vegetables, and the trend seems that will continuing in the coming years. In this respect, the particular course has been designed for students of Vegetable Science department.

**AIM OF THE COURSE**

To impart knowledge on recent developments in breeding for improved nutritional quality in important vegetable crops

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to:

1. Know about various special characters of vegetables
2. The recent breeding methods to achieve special characters in vegetables

**THEORY**

Important nutrient constituents in vegetables and their role in human diet. Genetics of nutrients. Genetic and genomic resources for improving quality traits in vegetables, breeding strategies for developing varieties with improved nutrition for market and industrial purposes. Molecular and biotechnological approaches in breeding suitable cultivars of different crops for micronutrients and colour content

**UNIT-I:** Brassica group, carrot and beetroot

**UNIT-II:** Tomato, brinjal, peppers and potato

**UNIT-III:** Green leafy vegetables, Legume crops and okra

**UNIT-IV:** Cucurbitaceous vegetable crops and edible Alliums

**UNIT-V:** Biofortification in vegetable crops, genetic engineering for improvement of quality traits in vegetable crops, bioavailability of dietary nutrients from improved vegetable crops and impact on micronutrient malnutrition, achievements and future prospects in breeding for quality traits in vegetables.

**TEACHING METHODS/ACTIVITIES**

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedure
- Group discussion

**SUGGESTED READINGS**

1. Allard, R.W. 1999. *Principles of plant breeding*. John Wiley and Sons.
2. Basset, M.J. (Ed.) 1986. *Breeding vegetable crops*. AVI Publ.
3. Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J. 2005. *Plant genetic resources: horticultural crops*. Narosa Publ. House.
4. Fageria, M.S., Arya, P.S. and Choudhary, A.K. 2000. *Vegetable crops: Breeding and seed production.* Vol. I. Kalyani.
5. Gardner, E.J. 1975. *Principles of genetics*. John Wiley and Sons.
6. Hayes, H.K., Immer, F.R. and Smith, D.C. 1955. *Methods of plant breeding*. McGraw-Hill.
7. Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.). 1993. *Plant Breeding-principles and prospects.* Chapman and Hall.
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10. Kalloo, G.1988. *Vegetable breeding.* Vols. I-III. CRC Press.
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12. Kumar, J.C. and Dhaliwal, M.S. 1990. *Techniques of developing hybrids in vegetable crops*. Agro BP.

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14. Peter, K.V. and Pradeepkumar, T. 2008. *Genetics and breeding of vegetables*. Revised.
15. Peter, K.V. and Hazra, P. (Eds) 2012. *Handbook of vegetables*. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p
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21. Simmonds, N.W. 1978. *Principles of crop improvement.* Longman.
22. Singh BD. 1983. *Plant Breeding*. Kalyani Publ.
23. Singh, P.K., Dasgupta, S.K. and Tripathi, S.K. 2004. *Hybrid vegetable development.* IBDC.
24. Swarup, V. 1976. *Breeding procedure for cross-pollinated vegetable crops*. ICAR.

## VSC 624 BIODIVERSITY AND CONSERVATION OF VEGETABLE CROPS 3(2+1)

**WHY THIS COURSE?**

The availability of pertinent gene pool is of utmost importance to mitigate adverse climate and to counter diseases and pests. In addition, specific gene sources (germplasm) would always be necessary to develop superior genotypes. Considering the importance of conserving biodiversity in vegetable crops for future use, the course has been designed.

**AIM OF THIS COURSE**

To understand the status and magnitude of biodiversity and strategies in germplasm conservation of vegetable crops.

The course is organised as follows:-

| S.No. | Block | Units |
|---|---|---|
| 1. | Biodiversity and conservation of vegetable crops | 1. General Aspects: Issues, Goals and Current Status |
| | | 2. Germplasm Conservation: Collection, Maintenance and Characterization |
| | | 3. Regulatory Horticulture: Germplasm Exchange, Quarantine and Intellectual Property Rights |

**COURSE OUTCOMES**

1. The student would be expected to learn about the significance of germplasm
2. Various strategies to conserve it in the present context.

**THEORY**

**UNIT-I:** *General aspects* : issues, goals and current status: Biodiversity and conservation; issues and goals- needs and challenges ; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/database of fruit crops in India**.**

**UNIT-II:** *Germplasm conservation*: collection, maintenance and characterization: Exploration and collection of germplasm; sampling frequencies ; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- *in situ* and *ex situ* strategies, on farm conservation; problem of recalcitrance- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

**UNIT-III:** *Regulatory horticulture* :Germplasm exchange, quarantine and intellectual property rights germplasm exchange, quarantine and intellectual property rights regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India.

**PRACTICAL**

1. Documentation of germplasm- maintenance of passport data and other records of accessions;
2. Field exploration trips and sampling procedures;
3. Exercise on *ex situ* conservation – cold storage, pollen/seed storage;
4. Cryopreservation;
5. Visits to national gene bank and other centres of PGR activities;
6. Detection of genetic constitution of germplasm;
7. Germplasm characterization using a standardised DUS test protocol;
8. Special tests with biochemical and molecular markers.

**TEACHING METHODS / ACTIVITIES**

- Class room lectures
- Laboratory / field practicals
- Student seminars / presentations
- Field tours / demonstrations
- Assignments

**SUGGESTED READINGS**


1. Dhillon, B. S., Tyagi, R. K., Lal, A. and Saxena, S. 2004. *Plant genetic resource management. – horticultural crops*. Narosa publishing house, New Delhi.
2. Engles, J.M., Ramanath R,V., Brown, A.H.D. and Jackson, M.T. 2002. *Managing plant genetic resources*, CABI, Wallingford, UK.
3. Frankel, O.H. and Hawkes, J.G. 1975. *Crop genetic resources for today and tomorrow*. Cambridge University Press, USA.
4. Hancock, J. 2012. *Plant evolution and the origin of crops species*. CAB International.
5. Jackson, M., Ford-Lloyd, B. and Parry, M. 2014. *Plant genetic resources and climate change*. CABI, UK
6. Moore, J.N. and Ballington, J.R. 1991. *Genetic resources of temperate Fruit and nut crops*. ISHS.
7. Peter, K.V. 2008. *Biodiversity of horticultural crops*. Vol. II. Daya Publ. House, Delhi.
8. Peter, K.V. 2011. *Biodiversity in horticultural crops*. Vol. III. Daya publ. house, Delhi.
9. Rajasekharan, P.E., Rao, V. and Ramanatha, V. 2019. *Conservation and utilization of horticultural genetic resources*. Springer.
10. Rana, J.C. and Verma, V.D. 2011. *Genetic resources of temperate minor fruits (indigenous and exotic)*. NBPGR, New Delhi.
11. Sthapit, *et al.* 2016. *Tropical fruit tree diversity (good practices for in situ and ex situ conservation)*. Bioversity International. Routledge, Taylor and Francis Group.
12. Virchow, D. 2012. *Conservation of genetic resources*, Springer Verlag, Berlin


## VSC 625 BIOTECHNOLOGICAL APPROACHES IN VEGETABLE CROPS 3(2+1)

**WHY THE COURSE?**

Biotechnology is a rapidly developing area of contemporary science. It can bring new ideas, improved tools and novel approaches to the solution of some persistent, seemingly intractable problems in vegetable production. Given the pressing need to enhance and stabilize the vegetable production in response to mounting population pressures and increasing awareness, there is an urgent need to explore novel technologies that will break traditional barriers.

**AIM OF THIS COURSE**

To impart latest knowledge in biotechnical advancement in vegetable crops

The course is organised as follows:-

| S.No. | Block | Units |
|---|---|---|
| 1. | Biotechnological approaches in vegetable crops | 1. Importance and scope of Biotechnology |
| | | 2. Somatic embryogenesis |
| | | 3. Blotting techniques, DNA finger printing |
| | | 4. Plant genetic engineering |
| | | 5. Concepts and methods of next generation sequencing (NGS) |

**COURSE OUTCOMES**

The student would be expected to learn

1. Different biotechnological tools
2. NGS, genetic engineering

**THEORY**

**Block 1:** Biotechnological approaches in vegetable crops

**UNIT-I:** *Importance and scope of biotechnology* - in vegetable crop improvement. *In vitro* culture, micro propagation, anther culture, pollen culture, ovule culture, embryo culture, endosperm culture.

**UNIT-II:** *Somatic embryogenesis* - somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion. Somatic hybrids and cybrids and their application in vegetable improvement programme.

**UNIT-III:** *Blotting techniques, DNA finger printing* - Molecular markers/DNA based markers and role. RFLP, AFLP, RAPD, SSR, SNPs, DNA probes. QTL mapping. MAS and its application in vegetable crop improvement. Allele mining by TILLING and Eco-TILLING.

**UNIT-IV:** *Plant genetic engineering* - Scope and importance, Concepts of cisgenesis, intragenesis and transgenesis. Gene cloning, direct and indirect methods of gene transfer. Role of RNAi based gene silencing in vegetable crop improvement. Bio-safety issue, regulatory issues for commercial approval.

**UNIT-V:** *Concepts and methods of next generation sequencing (NGS)*- Genome sequencing, transcriptomics, proteomics, metabolomics. Genome editing (ZFN, TALENS and CRISPER)

Crops: Solanaceous crops, cole crops, cucurbitaceous crops, root vegetables, garden pea, onion, potato and leafy vegetables

**PRACTICAL**

1. Micropropagation, Pollen- Ovule and Embryo culture- Synthetic seed production;
2. *In vitro* mutation induction, *in vitro* rooting – hardening at primary and secondary nurseries;
3. DNA isolation from economic vegetable crop varieties – Quantification and amplification (2) DNA and Protein profiling – molecular markers, PCR Handling;
4. Vectors for cloning and particle bombardment;
5. DNA fingerprinting of flower crop varieties;
6. Project preparation for establishment of low, medium and high cost tissue culture laboratories.

**TEACHING METHODS/ACTIVITIES**

- Class room lectures
- Laboratory/ field practicals
- Student seminars/ presentations
- Field tours/ demonstrations
- Assignments

**SUGGESTED READINGS**

1. Bajaj, Y.P.S. (Ed.) 1987. *Biotechnology in agriculture and forestry*. Vol. XIX. Hitech and Micropropagation. Springer.
2. Chadha, K.L., Ravindran, P.N. and Sahijram, L. (Eds.) 2000. *Biotechnology of horticulture and plantation crops.* Malhotra Publ. House.
3. Debnath, M. 2005. *Tools and techniques of biotechnology*. Pointer publication, New Delhi.
4. Glover, M.D. 1984. *Gene cloning: the mechanics of DNA manipulation*. Chapman and Hall.
5. Gorden, H. and Rubsell, S. 1960. *Hormones and cell culture*. AB Book Publ.
6. Keshavachandran, R. 2007. *Recent trends in biotechnology of horticultural crops*. NIPA.
7. Keshavachandran, R. and Peter, K.V. 2008. *Plant biotechnology; tissue culture and gene transfer*. Orient and Longman, USA.
8. Keshavachandran, R. 2007. *Recent trends in biotechnology of horticultural crops*. NIPA.
9. Panopoulas, N.J. (Ed.) 1981. *Genetic engineering in plant sciences*. Praeger Publ.
10. Parthasarathy, V.A., Bose, T.K., Deka, P.C., Das, P., Mitra, S.K. and Mohanadas, S. 2001. *Biotechnology of horticultural crops*. Vols. I-III. Naya Prokash.
11. Pierik, R.L.M. 1987. *In vitro culture of higher plants*. Martinus Nijhoff Publ.

12. Prasad, S. 1999. *Impact of plant biotechnology on horticulture*. 2nd Ed. Agro Botanica.
13. Rout, G.R. and Peter, K.V. 2018. *Genetic engineering of horticultural crops*. Academic press Elsveer.
14. Sharma, R. 2000. *Plant tissue culture*. Campus Books.
15. Singh, B.D. 2010. *Biotechnology- expanding horizons*. Kalyani Publishers, New Delhi.
16. Skoog, Y. and Miller, C.O. 1957. *Chemical regulation of growth and formation in plant tissue cultured in vitro.* Attidel. II Symp. On biotechnology action of growth substance.
17. Vasil, T.K., Vasi, M., While, D.N.R. and Bery, H.R. 1979. *Somatic hybridization and genetic manipulation in plants, plant regulation and world agriculture*. Planum Press.

## VSC 626 ADVANCED LABORATORY TECHNIQUES FOR VEGETABLE CROPS 3(1+2)

**WHY THE COURSE?**

Accurate quality analysis of vegetables warrants stringent measurement protocols besides requisite instruments/ tools and laboratory facilities. Consequently, a specialized course is designed for imparting basic and applied training on physical and biochemical assessment of the vegetable produce.

**AIM OF THIS COURSE**

To familiarize with the laboratory techniques for analysis of vegetable crops.
The organisation of the course is as under:-

| S.No. | Block | Units |
|---|---|---|
| 1. | Advanced laboratory techniques for vegetable crops | 1. Safety measures and laboratory maintenance |
| | | 2. Qualitative and quantitative analysis destructive and non-destructive analysis methods |
| | | 3. Chromatographic and microscopic analysis |
| | | 4. Sensory analysis |

**COURSE OUTCOMES**

The students would be expected to develop skills and expertise on
1. Upkeep of laboratories and handling of research instruments
2. Principles and methods of various analysis

**THEORY**

**UNIT-I:** *Safety measures and laboratory maintenance* - Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.

**UNIT-II:** *Destructive and non-destructive analysis methods*- Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops.

**UNIT-III:** *Chromatographic and microscopic analysis*- basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in horticultural produce.

**UNIT-IV:** *Sensory analysis* - Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.

**PRACTICAL**

1. Determination of moisture, relative water content and physiological loss in weight;
2. Determination of biochemical components in horticultural produce;
3. Calibration and standardization of instruments;
4. Textural properties of harvested produce;
5. Determination of starch index (SI);
6. Specific gravity for determination of maturity assessment, and pH of produce;
7. Detection of adulterations in fresh as well as processed products;

8. Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch;
9. Estimation of rate of ethylene evolution using gas chromatograph (GC);
10. Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, *etc.*).

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. AOAC International. 2003. *Official methods of analysis of AOAC international*. 17th Ed. Gaithersburg, MD, USA. *Association of analytical communities*, USA.
2. Clifton, M. and Pomeranz, Y. 1988. *Food analysis- laboratory experiments*. AVI publication, USA.
3. Linskens, H.F. And Jackson, J.F. 1995. *Fruit analysis*. Springer.
4. Leo, M.L. 2004. *Handbook of food analysis*, 2nd Ed. Vols. I-III, USA.
5. Pomrenz, Y. and Meloan, C.E. 1996. *Food analysis - theory and practice*. CBS, USA.
6. Ranganna, S. 2001. *Handbook of analysis and quality control for fruit and vegetable products*. 2nd Ed. Tata-McGraw-Hill, New Delhi.
7. Thompson, A.K. 1995. *Postharvest technology of fruits and vegetables*. Blackwell sciences. USA.

# COURSE CONTENTS: M.Sc. (Hort.) FRUIT SCIENCE

## FSC 511 TROPICAL FRUIT PRODUCTION 3(2+1)

**WHY THIS COURSE?**

Tropical fruits occupy a distinct place in global fruit production. Apart from ecological specificities, tropical fruits enjoy favour among masses being delicious and nutritious. As such, the course has been designed to provide update knowledge on various production technologies of tropical fruits on sustainable basis.

**AIM OF THIS COURSE**

To impart comprehensive knowledge to the students on cultural and management practices for growing tropical fruits.

The course is organised as follows:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | Importance and Background |
| 2. | Agro-Techniques | Propagation, Planting and Orchard Floor Management |
| 3. | Crop Management | Flowering, Fruit-Set and Harvesting |

**COURSE OUTCOMES**

The students are expected to equip themselves with know-how on agro-techniques for establishment and management of an orchard leading to optimum and quality fruit production of tropical fruits.

**THEORY**

**Block 1: Introduction**

**UNIT-I:** Importance and Background: Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, national and international importance, ecophysiological requirements.

**Block 2: Agro - Techniques**

**UNIT-I:** Propagation, Planting and Orchard Floor Management: Asexual and sexual methods of propagation, planting systems and planting densities, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of biofertilizers, role of bio-regulators, abiotic factors limiting fruit production.

**Block 3: Crop Management**

**UNIT-I:** Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders - causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

**CROPS:** Mango, Banana, Guava, Pineapple, Papaya, Sapota, Avocado, Jackfruit, Annonas, Aonla and Ber

**PRACTICAL**

1. Distinguished features of tropical fruit species, cultivars and rootstocks (2)
2. Demonstration of planting systems, training and pruning (3)
3. Hands on practices on pollination and crop regulation (2)
4. Leaf sampling and nutrient analysis (2)
5. Nutrient management and fertilizer application (1)
6. Physiological disorders-malady diagnosis (1)
7. Physico-chemical analysis of fruit quality attributes (2)
8. Maturity indices and post-harvest handling of fruit crops (1)
9. Field/Exposure visits to tropical orchards (1)
10. Project preparation for establishing commercial orchards (1)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations

- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. Bartholomew, D.P., Paull, R.E. and Rohrbach, K.G. 2002. *The Pineapple: Botany, Production, and Uses.* CAB International.
2. Bose, T, K., Mitra, S.K. and Sanyal, D., 2002. *Fruits of India– Tropical and Sub-Tropical.* 3rd Edn. Naya Udyog, Kolkata.
3. Dhillon, W.S., 2013. *Fruit Production in India.* Narendra Publ. House, New Delhi.
4. Iyer, C. P. A. and Kurian, R. M. 2006. *High Density Planting in Tropical Fruits: Principles and Practices.* IBDC Publishers, New Delhi.
5. Litz, R.E. 2009. *The Mango : Botany, Production and Uses*. CAB International.
6. Madhawa Rao, V. N. 2013. *Banana.* ICAR, New Delhi.
7. Midmore, D. 2015. *Principles of Tropical Horticulture.* CAB International.
8. Mitra, S. K. and Sanyal, D. 2013. *Guava.* ICAR, New Delhi.
9. Morton, J F. 2013. *Fruits of Warm Climates.* Echo Point Book Media, USA.
10. Nakasome, H. Y and Paull, R. E. 1998. *Tropical Fruits.* CAB International.
11. Paull, R.E. and Duarte, O., 2011. *Tropical Fruits* (Vol. 1). CAB International.
12. Rani, S., Sharma, A. and Wali, V. K. 2018. *Guava (Psidium guajava L.)*. Astral, New Delhi.
13. Robinson, J.C. and Saúco, V.G. 2010. *Bananas and Plantains.* CAB International.
14. Sandhu, S. and Gill, B.S. 2013. *Physiological Disorders of Fruit Crops.* NIPA, New Delhi
15. Schaffer, B., Wolstenholme, B. N. and Whiley, A. W. 2013. *The Avocado: Botany, Production and Uses.* CAB International
16. Sharma, K. K. and Singh, N. P. 2011. *Soil and Orchard Management.* Daya Publishing House, New Delhi.
17. Valavi, S.G., Peter, K.V. and Thottappilly, G., 2011. *The Jackfruit.* Stadium Press, USA.

## FSC 512 SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION 3(2+1)

**WHY THIS COURSE?**

Agro-climatic diversity in India facilitates growing a wide range of fruits extending from tropical to subtropical to temperate fruits and nuts. To highlight their ecological specificities, seasonal variations and pertinent cultural practices, a course is designed exclusively for subtropical and temperate fruits.

**AIM OF THIS COURSE**

To impart comprehensive knowledge to the students on cultural and management practices for growing subtropical and temperate fruits.

The course is organised as fellows:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | Importance and Background |
| 2. | Agro-Techniques | Propagation, Planting and Orchard Floor Management |
| 3. | Crop Management | Flowering, Fruit-Set and Harvesting |

**COURSE OUTCOMES**

After successful completion of the course, the student are expected to equip themselves with

1. Principles and practices of producing subtropical (citrus, grapes, litchi, pomegranate *etc.*) and temperate fruits (apple, pear, peach, plum, apricot, cherries, berries, kiwifruit *etc.*) and nuts (almond, walnut, pecan *etc.*)

**THEORY**

**Block 1: Introduction**

**UNIT**-I: Importance and Background: Origin, distribution and importance, major species, rootstocks and commercial varieties of regional, national and international importance, ecophysiological requirements.

**Block 2: Agro - Techniques**

**UNIT**-I: Propagation, Planting and Orchard Floor Management: Propagation, planting systems and densities, training and pruning, rejuvenation and replanting, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

**Block 3: Crop Management**

**UNIT**-I: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders- causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

**CROPS:** Citrus, Grapes, Litchi, Pomegranate, Datepalm, Strawberry, Apple, Pear, Peach, Plum, Apricot, Cherries, Berries, Persimmon, Kiwifruit, Nuts- Walnut, Almond and Pecan

**PRACTICAL**

1. Distinguished features of fruit species, cultivars and rootstocks (2)
2. Demonstration of planting systems, training and pruning (3)
3. Hands on practices on pollination and crop regulation (2)
4. Leaf sampling and nutrient analysis (3)
5. Physiological disorders-malady diagnosis (1)
6. Physico-chemical analysis of fruit quality attributes (3)
7. Field/Exposure visits to subtropical and temperate orchards (1)
8. Project preparation for establishing commercial orchards (1)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**


1. Chadha, K.L. and Awasthi, R.P. 2005. *The Apple.* Malhotra Publishing House, New Delhi.
2. Chadha, T.R. 2011. *A Text Book of Temperate Fruits.* ICAR, New Delhi
3. Childers, N. F., Morris, J. R. and Sibbett, G. S. 1995. *Modern Fruit Science: Orchard and Small Fruit Culture.* Horticultural Publications, USA.
4. Creasy, G and Creasy L. 2018. *Grapes.* CAB International.
5. Davies, F.S. and Albrigo, L.G., 1994. *Citrus.* CAB International.
6. Dhillon, W.S., 2013. *Fruit Production in India.* Narendra Publishing House, New Delhi.
7. Jackson, D., Thiele, G., Looney, N. E. and Morley-Bunker, M. 2011. *Temperate and Subtropical Fruit Production.* CAB International.
8. Ladanyia, M., 2010. *Citrus Fruit: Biology, Technology and Evaluation.* Academic Press.
9. Layne, D.R. and Bassi, D. 2008. *The Peach: Botany, Production and Uses.* CABI.
10. Menzel, C. M. and Waite, G. K. 2005. *Litchi and Longan: Botany, Production and Uses.* CAB International.
11. Pandey , R. M. and Randey, S. N. 1996. *The Grape in India.* ICAR, New Delhi.
12. Rajput, C.B.S. and Haribabu, R.S. 2006. *Citriculture.* Kalyani Publishers, New Delhi.
13. Sandhu, S. and Gill, B. S. 2013. *Physiological Disorders of Fruit Crops.* NIPA, New Delhi.
14. Sharma, R. M., Pandey, S. N. and Pandey, V. 2015. *The Pear- Production, Postharvest Management and Protection.* IBDC Publisher, New Delhi.
15. Sharma, R. R. and Krishna, H., 2018. *Textbook of Temperate Fruits.* CBS Publishers and Distributors Pvt. Ltd., New Delhi.
16. Singh, S., Shivshankar, V. J, Srivastava, A. K. and Singh I. P. 2004. *Advances in Citriculture*. NIPA, New Delhi.
17. Tromp, J., Webster, A. S. and Wertheim, S. J. 2005. *Fundamentals of Temperate Zone Tree Fruit Production.* Backhuys Publishers, Lieden, The Netherlands.
18. Webster, A. and Looney, N. *Cherries: Crop Physiology, Production and Uses*. CABI.
19. Westwood, M. N. 2009. *Temperate Zone Pomology: Physiology & Culture*. Timber Press, USA.

## FSC 513 PROPAGATION AND NURSERY MANAGEMENT OF FRUIT CROPS 3(2+1)

**WHY THIS COURSE?**

Availability of sufficient and healthy planting material is pivotal for expanding fruit culture. This necessitates requisite skill and efficient multiplication protocols for raising plants and their in house management prior to distribution or field transfer, hence the course is developed.

**AIM OF THIS COURSE**

To understand the principles and methods of propagation and nursery management in fruit crops. The course is organised as follows:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | 1. General Concepts and Phenomena |
| 2. | Propagation | 1. Conventional Asexual Propagation |
| | | 2. Micropropagation |
| 3. | Nursery Management | 1. Practices and Regulation |

**COURSE OUTCOMES**

The student would be expected to equip to acquire skills and knowledge on principles and practices of macro and micropropagation and the handling of propagated material in nursery.

**THEORY**

**Block 1: Introduction**

**UNIT-1:** General Concepts and Phenomena: Introduction, understanding cellular basis for propagation, sexual and asexual propagation, apomixis, polyembryony, chimeras. Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seed germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing.

**Block 2: Propagation**

**UNIT-I:** Conventional Asexual Propagation: Cutting– methods, rooting of soft and hardwood cuttings under mist and hotbeds. Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering– principle and methods. Budding and grafting – principles and methods, establishment and management of bud wood bank. Stock, scion and inter stock relationship - graft incompatibility, physiology of rootstock and top working.

**UNIT-II:** Micropropagation: Micro-propagation- principles and concepts, commercial exploitation in horticultural crops. Techniques- in vitro clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules.

**Block 3: Nursery**

**UNIT-I:** Management Practices and Regulation: Nursery– types, structures, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, nursery accreditation, import and export of seeds and planting material and quarantine.

**PRACTICAL**

1. Hands on practices on rooting of dormant and summer cuttings (3)
2. Anatomical studies in rooting of cutting and graft union (1)
3. Hands on practices on various methods of budding and grafting (4)
4. Propagation by layering and stooling (2)
5. Micropropagation- explant preparation, media preparation, culturing – meristem tip culture, axillary bud culture, micro-grafting, hardening (4)
6. Visit to commercial tissue culture laboratories and accredited nurseries (2)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**


1. Bose, T. K., Mitra, S. K. and Sadhu, M.K., 1991. *Propagation of Tropical and Subtropical Horticultural Crops.* Naya Prokash, Kolkata.
2. Davies, F.T, Geneve, R.L. and Wilson, S.B. 2018. *Hartmann and Kester's Plant Propagation-Principles and Practices.* Pearson, USA/Prentice Hall of India. New Delhi.
3. Gill, S. S., Bal, J. S. and Sandhu, A. S. 2016. *Raising Fruit Nursery*. Kalyani Publishers, New Delhi.
4. Jain, S. and Ishil, K. 2003. *Micropropagation of Woody Trees and Fruits*. Springer.
5. Jain, S. and Hoggmann, H. 2007. *Protocols for Micropropagation of Woody Trees and Fruits.* Springer.
6. Joshi, P. 2015. *Nursery Management of Fruit Crops in India.* NIPA, New Delhi.
7. Love *et al.* 2017. *Tropical Fruit Tree Propagation Guide.* UH-CTAHR F_N_49. College of Tropical Agriculture and Human Resources University of Hawaii at Manawa, USA.
8. Peter, K.V., eds., 2008. *Basics of Horticulture.* New India Publishing Agency, New Delhi.
9. Rajan, S. and Baby, L.M., 2007. *Propagation of Horticultural Crops.* NIPA, New Delhi.
10. Sharma, R.R., 2014. *Propagation of Horticultural Crops.* Kalyani Publishers, New Delhi.
11. Sharma, R.R. and Srivastav, M., 2004. *Propagation and Nursery Management.* Intl. Book Publishing Co., Lucknow.
12. Singh, S. P. 1989. *Mist Propagation.* Metropolitan Book Co.
13. Singh, R. S. 2014. *Propagation of Horticultural Plants: Arid and Semi-Arid Regions.* NIPA, New Delhi.
14. Tyagi, S. 2019. *Hi-Tech Horticulture. Vol I: Crop Improvement, Nursery and Rootstock Management.* NIPA, New Delhi.


## FSC 521 BREEDING OF FRUIT CROPS 3(2+1)

**WHY THIS COURSE?**

Development of genetically improved varieties and rootstock is a continuous process which is realized through selection and breeding approaches. This is necessary to enhance the productivity and meet ever-changing climatic conditions and market / consumer preferences. As such, a course is formulated to generate know-how on genetic and breeding aspects of fruit crops.

**AIM OF THIS COURSE**

To impart comprehensive knowledge on principles and practices of fruit breeding.
The course organisation is as under:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | Importance, Taxonomy and Genetic Resources |
| 2. | Reproductive Biology | Blossom Biology and Breeding Systems |
| 3. | Breeding approaches | Conventional and Non-Conventional Breeding |

**COURSE OUTCOMES**

After successful completion of the course, the students are expected to
1. Have an understanding on importance and peculiarities of fruit breeding
2. Have an updated knowledge on reproductive biology, genetics and inherent breeding systems.
3. Have detailed knowledge of various methods / approaches of breeding fruit crops

**THEORY**

**Block 1: Introduction**

**UNIT-I:** Importance, Taxonomy and Genetic Resources: Introduction and importance, origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources.

**Block 2: Reproductive Biology**

**UNIT-I:** Blossom Biology and Breeding Systems: Blossom biology, breeding systems – spontaneous mutations, polyploidy, incompatibility, sterility, parthenocarpy, apomixis, breeding objectives, ideotypes.

**Block 3: Breeding Approaches**

**UNIT-I:** Conventional and Non-Conventional Breeding: Approaches for crop improvement – direct introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrusts.

**CROPS:** Mango, Banana, Pineapple, Citrus, Grapes, Litchi, Guava, Pomegranate, Ber, Date palm Papaya, Apple, Pear, Plum, Peach, Apricot, Strawberry, Nuts.

**PRACTICAL**

1. Exercises on bearing habit, floral biology (2)
2. Pollen viability and fertility studies (1)
3. Hands on practices in hybridization (3)
4. Raising and handling of hybrid progenies (2)
5. Induction of mutations and polyploidy (2)
6. Evaluation of biometrical traits and quality traits (2)
7. Screening for resistance against abiotic stresses (2)
8. Developing breeding programme for specific traits (2)
9. Visit to research stations working on fruit breeding (1)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**


1. Abraham, Z. 2017. *Fruit Breeding.* Agri-Horti Press, New Delhi.
2. Badenes, M.L. and Byrne, D.H. 2012. *Fruit Breeding.* Springer Science, New York.
3. Dinesh, M.R. 2015. *Fruit Breeding*. New India Publishing Agency, New Delhi.
4. Ghosh, S.N. Verma, M.K. and Thakur, A. 2018. *Temperate Fruit Crop Breeding- Domestication to Cultivar Development.* NIPA, New Delhi.
5. Hancock, J.F. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. Springer Science, NY.
6. Jain, S.N. and Priyadarshan, P.M. 2009. *Breeding Plantation and Tree Crops: Tropical Species*. Springer Science, New York.
7. Janick, J. and Moore, J.N. 1996. *Fruit Breeding*. Vols. I - III. John Wiley & Sons, USA.
8. Kumar, N. 2014. *Breeding of Horticultural Crops: Principles& Practices*. NIPA, N. Delhi.
9. Moore, J.N. and Janick, J. 1983. *Methods in Fruit Breeding*. Purdue University Press, USA.
10. Ray, P.K. 2002. *Breeding Tropical and Subtropical Fruits*. Narosa Publ. House, New Delhi.


## FSC 522 GROWTH AND DEVELOPMENT OF FRUIT CROPS 3(2+1)

**WHY THIS COURSE?**

The underlying principles and parameters of growth and development needs to be understood for harnessing maximum benefits in term of yield and quality. External environment and inherent hormonal and metabolic pathways considerably determine growth dynamics. Thus, a course is formulated to develop know-how on physiological and physical aspects of growth and development processes.

**AIM OF THIS COURSE**

To develop comprehensive understanding on growth and development of fruit crops.
The course is structured as under:-

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | General Concepts and Principles |
| 2. | Environment and Development | Climatic Factors, Hormones and Developmental Physiology |
| 3. | Stress Management | Strategies for Overcoming Stress |

**COURSE OUTCOMES**

Consequent upon successful completion of the course, the students are expected to have

1. Equipped with understanding of various growth and development processes
2. Learned about the role of environment and growth substances
3. Acquired the skills to realise optimum growth and development under stress conditions

**THEORY**

**Block 1: Introduction**

**UNIT-I:** General Concepts and Principles: Growth and development- definition, parameters of growth and development, growth dynamics and morphogenesis.

**Block 2: Environment and Development**

**UNIT-I:** Climatic Factors, Hormones and Developmental Physiology: Environmental impact on growth and development- effect of light, temperature, photosynthesis and photoperiodism, vernalisation, heat units and thermoperiodism. Assimilate partitioning, influence of water and mineral nutrition in growth and development; concepts of plant hormone and bioregulators, history, biosynthesis and physiological role of auxins, gibberellins, cytokinins, abscissic acid, ethylene, growth inhibitors and retardant, brasssinosteroids, other New PGRs. Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development.

**Block 3: Stress Management**

**UNIT-I:** Strategies for Overcoming Stress: Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations and Commercial application of PGRs in fruit crops, molecular and genetic approaches in plant growth and development.

**PRACTICAL**

1. Understanding dormancy mechanisms in fruit crops and seed stratification (2)
2. Techniques of growth analysis (2)
3. Evaluation of photosynthetic efficiency under different environments (2)
4. Exercises on hormone assays (2)
5. Practicals on use of growth regulators (2)
6. Understanding ripening phenomenon in fruits (2)
7. Study on impact of physical manipulations on growth and development (1)
8. Study on chemical manipulations on growth and development (1)
9. Understanding stress impact on growth and development (1)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**


1. Bhatnagar, P. 2017. *Physiology of Growth and Development of Horticultural Crops*. Agrobios (India).
2. Buchanan, B., Gruiessam, W. and Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*. John Wiley & Sons, NY, USA.
3. Dhillon, W.S. and Bhatt, Z. A., 2011. *Fruit Tree Physiology*. Narendra Pub. House, New Delhi.
4. Durner, E. 2013. *Principles of Horticultural Physiology*. CAB International.
5. Epstein, E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. John Wiley & Sons, NY, USA.
6. Faust, M.1989. *Physiology of Temperate Zone Fruit Trees*. John Willey & Sons, NY, USA.
7. Fosket, D.E.1994. *Plant Growth and Development: a Molecular Approach*. Academic Press, USA.
8. Leopold, A.C. and Kriedermann, P.E., 1985. *Plant Growth and Development*. 3rd Ed. McGraw-Hill, New Delhi.
9. Roberts, J., Downs, S. and Parker, P., 2002. *Plant Growth Development*. In: Salisbury, F.B. and Ross, C.W. (Eds.) Plant Physiology.4th Ed. Wadsworth Publications, USA.
10. Schafeer, B. and Anderson, P. 1994. *Handbook of Environmental Physiology of Fruit Crops*. Vol. 1 & 2. CRC Press. USA.
11. Seymour, G. B., Taylor, J. E. and Tucker, G.A.,1993. *Biochemistry of Fruit Ripening*. Chapman & Hall, London.

## FSC 523 NUTRITION OF FRUIT CROPS 3(2+1)

**WHY THIS COURSE?**

Nutrients play a significant role in almost every growth and development process determining vigour, yield and quality of fruits. Henceforth, a course is designed to have an in depth study of various nutrients, their uptake and use efficiency in realizing sustainable fruit production

**AIM OF THIS COURSE**

To acquaint with principles and practices involved in nutrition of fruit crops

The course is organised as under:-

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | General Concepts and Principles |
| 2. | Requirements and Applications | Diagnostics, Estimation and Application |
| 3. | Newer Approaches | Integrated Nutrient Management (INM) |

**COURSE OUTCOMES**

After successful completion of the course, the students would be expected to

1. Know the importance and various types of nutrients and their uptake mechanisms
2. Analyse soil and plant status with respect to various nutrients
3. Make use of corrective measures to overcome deficiency or toxicity

**THEORY**

**Block 1: Introduction**

**UNIT-I:** General Concepts and Principles: Importance and history of nutrition in fruit crops, essential plant nutrients, factors affecting plant nutrition; nutrient uptake and their removal from soil.

**Block 2: Requirements and Applications**

**UNIT-I:** Diagnostics, Estimation and Application: Nutrient requirements, root distribution in fruit crops, soil and foliar application of nutrients in major fruit crops, fertilizer use efficiency. Methods and techniques for evaluating the requirement of macro- and microelements, Diagnostic and interpretation techniques including DRIS. Role of different macro and micro-nutrients, their deficiency and toxicity disorders, corrective measures to overcome deficiency and toxicity disorders.

**Block 3: Newer Approaches**

**UNIT-I:** Integrated Nutrient Management (INM): Fertigation in fruit crops, bio-fertilizers and their use in INM systems. Organic nutrient management in fruit crops.

**PRACTICAL**

1. Visual identification of nutrient deficiency symptoms in fruit crops (2)
2. Identification and application of organic, inorganic and bio-fertilizers (1)
3. Soil/tissue collection and preparation for macro- and micro-nutrient analysis (1)
4. Analysis of soil physical and chemical properties- pH, EC, Organic carbon (1)
5. Determination of N,P,K and other macro- and micronutrients (6)
6. Fertigation in glasshouse and field grown horticultural crops (2)
7. Preparation of micro-nutrient solutions, their spray and soil applications (2)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. Atkinson, D., Jackson, J.E. and Sharples, R.O. 1980. *Mineral Nutrition of Fruit Trees.* Butterworth – Heinemann.
2. Bould, C., Hewitt, E.J. and Needham, P. 1983. *Diagnosis of Mineral Disorders in Plants Vol.1 Principles.* Her Majesty's Stationery Office, London.
3. Cooke, G.W. 1972. *Fertilizers for maximizing yield.* Grenada Publishing Ltd, London.

4. Epstein, E. 1972. *Mineral Nutrition of Plants: Principles & Perspectives*. Wiley Eastern Ltd.
5. Kanwar, J.S. 1976. *Soil Fertility- Theory and Practice*. ICAR, New Delhi.
6. Marchner, Horst. 1995. *Mineral Nutrition of Higher Plants*, 2nd Ed. Marschner, Academic Press Inc. San Diego, CA.
7. Mengel, K. and Kirkby, E.A. 1987. *Principles of Plant Nutrition*. 4th Ed. International Potash Institute, Worblaufen-Bern, Switzerland.
8. Prakash, M. 2013. *Nutritional Disorders in Fruit Crops: Diagnosis and Management*. NIPA, New Delhi.
9. Tandon, H.L.S. 1992. *Management of Nutrient Interactions in Agriculture*. Fertilizer Development and Consultation Organization, New Delhi.
10. Westerman, R.L. 1990. *Soil Testing and Plant Analysis*.3rd Ed. Soil Science Society of America, Inc., Madison, WI.
11. Yawalkar, K.S., Agarwal, J.P. and Bokde, S. 1972. *Manures and Fertilizers*. 3rd Ed. Agri Horticultural Publishing House, Nagpur.


## FSC 524 SYSTEMATICS OF FRUIT CROPS 3(2+1)

**WHY THIS COURSE?**

Life forms and their behaviour are best understood if properly described to the stake holders. Therefore, identification and characterization are pre-requisites to distinctly describe the plant species. The fruit crop species are no exception, and thus an exclusive course on their categorisation and description exhibiting a great deal of variation.

**AIM OF THIS COURSE**

To acquaint with the classification, nomenclature and description of various fruit crops.

The course is organised as under:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | Biosystematics | Nomenclature and Classification |
| 2. | Botanical Keys and Descriptors | Identification and Description |
| 3. | Special Topics | Registration and Modern Systematics |

**COURSE OUTCOMES**

After successful completion of the course, the students would be able to

1. Categorise different fruit species into broad groups.
2. Identify various fruit cultivars on basis of distinguishing features
3. Characterize fruit cultivars for description, registration and protection

**THEORY**

**Block 1: Biosystematics**

**UNIT-I:** Nomenclature and Classification: Biosystematics – introduction and significance; history of nomenclature of cultivated plants, classification and nomenclature systems; International code of nomenclature for cultivated plants

**Block 2: Botanical Keys and Descriptors**

**UNIT-I**: Identification and Description: Methods of identification and description of cultivated fruit and nut species and their wild relatives features; development of plant keys for systematic identification and classification.

Development of fruit crop descriptors- based upon Bioversity International Descriptors and UPOV/DUS test guidelines, botanical and pomological description of major cultivars and rootstocks of tropical, subtropical and temperate fruits and nut crops

**Block 3: Special Topics**

**UNIT-I**: Registration and Modern Systematics: Registration, Use of chemotaxonomy, biochemical and molecular markers in modern systematics

**PRACTICAL**

1. Exercises on identification and pomological description of various fruit species & cultivars (6)
2. Development of descriptive blanks vis-a-vis UPOV/DUS test guidelines and Bioversity International (4)
3. Descriptors for developing fruit species and cultivar descriptive databases (4)

4. Visits to major germplasm centres and field gene banks (2)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. ASHS, 1997. *The Brooks & Olmo Register of Fruit and Nut Varieties.* 3rd Ed. ASHS Press.
2. Bhattacharya, B. and Johri, B.M. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Pub. House, New Delhi.
3. Pandey, B.P. 1999. *Taxonomy of Angiosperms*. S. Chand & Co. New Delhi.
4. Pareek, O.P. and Sharma, S., 2017. *Systematic Pomology*. Scientific Publishers, Jodhpur.
5. Sharma, G., Sharma, O.C. and Thakur, B.S. 2009. *Systematics of Fruit Crops*. NIPA, New Delhi.
6. Simpson, M. 2010. *Plant Systematics*. 2nd Edn. Elsevier.
7. Spencer, R.R. Cross, R. and Lumley, P. 2003. *Plant Names*. 3rd Ed. A Guide to Botanical Nomenclature. CISRO, Australia.
8. Srivastava, U, Mahajan, R.K., Gangopadyay, K.K., Singh, M. and Dhillon, B.S. 2001. *Minimal Descriptors of Agri-Horticultural* Crops. I: Fruits. NBPGR, New Delhi.
9. Zielinski, Q. B. 1955. *Modern Systematic Pomology*. Wm. C. Brown Co., Iowa, USA.

## FSC 525 CANOPY MANAGEMENT OF FRUIT CROPS 2(1+1)

**WHY THIS COURSE?**

Plant architecture plays an important role in enhancing photosynthetic efficiency and resultant quantity and quality of the fruit produce. Manipulation of plant growth and development can be done by employing different training and pruning procedures besides through the use of growth regulators, specific rootstocks *etc*. Hence this course is developed to address the aforesaid issues.

**AIM OF THIS COURSE**

To impart knowledge on principles and practices in management of canopy architecture for quality fruit production.

The course organisation is as follows:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | Canopy Architecture | Introduction, types and Classification |
| 2. | Canopy Management | Physical Manipulation and Growth regulation |

**COURSE OUTCOMES:**

After successful completion of the course, the students are expected to learn

1. The basic principles of canopy management to modify plant architecture
2. The skills on training and pruning of fruit crops, and growth regulation

**THEORY**

**Block 1: Canopy Architecture**

**UNIT-I**: Introduction, Types and Classification: Canopy management - importance and factors affecting canopy development. Canopy types and structures, canopy manipulation for optimum utilization of light and its interception. Spacing and utilization of land area - Canopy classification.

**Block 2: Canopy Management**

**UNIT-I**: Physical Manipulation and Growth Regulation: Canopy management through rootstock and scion. Canopy management through plant growth regulators, training and pruning and management practices. Canopy development and management in relation to growth, flowering, fruiting and fruit quality. Training and pruning in Ber, Gauava, Pomegranate and Grape.

**PRACTICAL**

1. Study of different types of canopies (2)

2. Training of plants for different canopy types (2)
3. Canopy development through pruning (2)
4. Understanding bearing behaviour and canopy management in different fruits (2)
5. Use of plant growth regulators (2)
6. Geometry of planting (1)
7. Development of effective canopy with support system (2)
8. Study on effect of different canopy types on production and quality of fruits (2)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. Bakshi, J.C., Uppal, D.K. and Khajuria, H.N. 1988. *The Pruning of Fruit Trees and Vines*. Kalyani Publishers, New Delhi.
2. Chadha, K. L. and Shikhamany, S. D., 1999. T*he Grape, Improvement, Production and Post-Harvest Management*. Malhotra Publishing House, Delhi.
3. Iyer, C. P. A. and Kurian, R. M. 2006. *High Density Planting in Tropical Fruits: Principles and Practices*. IBDC Publishers, New Delhi.
4. Pradeepkumar, T. 2008. *Management of Horticultural Crops*. NIPA, New Delhi.
5. Singh, G. 2010. *Practical Manual on Canopy Management in Fruit Crops*. Dept. of Agriculture and Co-operation, Ministry of Agriculture (GoI), New Delhi.
6. Srivastava, K. K., 2012. *Canopy Management in Fruits*. ICAR, New Delhi.

## FSC 526 BIOTECHNOLOGY OF FRUIT CROPS 3(2+1)

**WHY THIS COURSE?**

In the recent times, biotechnological interventions in fruit crops have contributed in enhanced yield, biotic and abiotic stress management and improved quality traits to a considerable extent. Hence, a course is designed to educate on the possibilities and progress made through biotechnology for improved fruit production.

**AIM OF THIS COURSE**

To impart knowledge on the principles and tools of biotechnology.

Structure of the course is as under:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | General Background | Introduction, History and Basic Principles |
| 2. | Tissue Culture | *In vitro* Culture and Hardening |
| 3. | Genetic Manipulation | *In vitro* Breeding, Transgenics and Gene Technologies |

**COURSE OUTCOMES**

After the successful completion of the course, the students are expected to know

1. Basic principles and methods of plant tissue culture and other biotechnological tools.
2. The use and progress of biotechnology in fruit crops.

**THEORY**

**Block 1: General Background**

**UNIT-I:** Introduction, History and Basic Principles: Introduction and significance, history and basic principles, influence of explant material, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture

**Block 2: Tissue Culture**

**UNIT-I:** *In vitro* Culture and Hardening: Callus culture– types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis; Organ culture– meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture. Use of bioreactors and in vitro methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues. Hardening and ex vitro establishment of tissue cultured plants

**Block 3: Genetic Manipulation**

**UNIT-I:** *In vitro* Breeding, Transgenics and Gene Technologies: Somatic cell hybridisation, construction and identification of somatic hybrids and cybrids, wide hybridization, in vitro pollination and fertilization, haploids, in vitro mutation, artificial seeds, cryopreservation, In vitro selection for biotic and abiotic stress. Genetic engineering- principles and methods, transgenics in fruit crops, use of molecular markers and genomics. Gene silencing, gene tagging, gene editing, achievements of biotechnology in fruit crops.

**PRACTICAL**

1. An exposure to low cost, commercial and homestead tissue culture laboratories (2)
2. Media preparation, Inoculation of explants for clonal propagation, callus induction and culture, regeneration of plantlets from callus (3)
3. Sub -culturing techniques on anther, ovule, embryo culture, somaclonal variation (4)
4. In vitro mutant selection against abiotic stress (2)
5. Protoplast culture and fusion technique (2)
6. Development of protocols for mass multiplication (2)
7. Project development for establishment of commercial tissue culture laboratory (1)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**


1. Bajaj, Y.P.S., Eds., 1989. *Biotechnology in Agriculture and Forestry*. Vol. V, Fruits. Springer, USA.
2. Brown, T.A., 2001. *Gene Cloning and DNA Analysis and Introduction*. Blackwell Publishing, USA.
3. Chahal, G.S. and Gosal, S.S., 2010. *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches*. Narosa, New Delhi.
4. Chopra, V.L. and Nasim, A., 1990. *Genetic Engineering and Biotechnology– Concepts, Methods and Applications*. Oxford & IBH, New Delhi.
5. Keshavachandran, R. and Peter, K.V. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer*. Orient & Longman, Universal Press, US.
6. Keshavachandran. R., Nazeem, P.A., Girija, D., John, P.S. and Peter, K.V. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. Vols. I, II. NIPA, New Delhi.
7. Kale, C. 2013. *Genome Mapping and Molecular Breeding in Plant.* Vol 4 Fruit and Nuts. Springer.
8. Litz, R. E. 2005. *Biotechnology of Fruit and Nut Crops*. CABI, UK.
9. Miglani, G.S. 2016. *Genetic Engineering– Principles, Procedures and Consequences*. Narosa Publishing House, New Delhi.
10. Parthasarathy, V.A,, Bose, T.K., Deka, P.C., Das, P., Mitra, S.K. and Mohanadas, S. 2001. *Biotechnology of Horticultural Crops*. Vols. I-III. Naya Prokash, Kolkata.
11. Peter, K.V.2013. *Biotechnology in Horticulture: Methods& Applications*. NIPA, New Delhi.
12. Vasil, T.K., Vasi, M., While, D.N.R. and Bery, H.R. 1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture*. Platinum Press, UK.


## FSC 527 ORGANIC FRUIT CULTURE 3(2+1)

**WHY THIS COURSE?**

Considering threats to environment and human health on account of excessive use of chemicals and synthetic fertilizers, organic farming is looked upon as an alternative. Though the organic and other natural farming practices are in evolving phase and are yet to be time scale tested, there is a general perception that these would hold good. As such a course is customised to educate the Graduates on various issues related to organic farming.

**AIM OF THIS COURSE**

To develop understanding on organic production of fruit crops.

The course is structured as under:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | General Aspects | Principles and Current Scenario |
| 2. | Organic Culture | Farming System and Practices |
| 3. | Certification | Inspection, Control Measures and Certification |

**COURSE OUTCOMES**

On successful completion of the course, the students are expected to be able to
1. Familiarize with the concepts and practices of organic and other natural farming systems
2. Generate know-how on procedures, policies and regulation for inspection and certification of organic produce

**THEORY**

**Block 1: General Aspects**

**UNIT-I:** Principles and Current Scenario: Organic horticulture, scope, area, production and world trade, definition, principles, methods and SWOT analysis.

**Block 2: Organic Culture**

**UNIT-I:** Farming System and Practices: Organic farming systems including biodynamic farming, natural farming, homa organic farming, rishi krishi, EM technology, cosmic farming ; on-farm and off-farm production of organic inputs, role of bio-fertilizers, bio enhancers, legumes, inter cropping, cover crops, green manuring, zero tillage, mulching and their role in organic nutrition management. Organic seeds and planting materials, soil health management in organic production, weed management practices in organic farming, biological management of pests and diseases, trap crops, quality improvement in organic production of fruit crops.

**Block 3: Certification**

**UNIT-I:** Inspection, Control Measures and Certification: Inspection and certification of organic produce, participatory guarantee system (PGS), NPOP, documentation and control, development of internal control system (ICS), Concept of group certification, constitution of grower group as per NPOP, preparation of ICS manual, internal and external inspection, concept of third party verification, certification of small farmer groups (Group Certification),transaction certificate, group certificate, critical control points (CCP) and HACCP, IFOAM guidelines on certification scope and chain of custody, certification trademark – The Logo, accredited certification bodies under NPOP. Constraints in certification, IFOAM and global scenario of organic movement, postharvest management of organic produce. Economics of organic fruit production

**PRACTICAL**

1. Design of organic orchards/farms management (1)
2. Conversion plan (1)
3. Nutrient management and microbial assessment of composts and bio-enhancers (2)
4. Preparation and application of composts, bio-enhancers and bio-pesticides (2)
5. Organic nursery raising (1)
6. Application of composts, bio-enhancers, bio-fertilisers and bio-pesticides, green manure, cover, mulching (2)
7. Preparation and use of neem based products (1)
8. Biodynamic preparations and their role in organic agriculture, EM technology and products, biological/natural management of pests and diseases (2)
9. Soil solarisation (1)
10. Frame work for GAP (1)
11. Documentation for certification (1)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. Claude, A. 2004. *The Organic Farming Sourcebook*. Other India Press, Mapusa, Goa, India.

2. Dabholkar, S.A. 2001. *Plenty for All*. Mehta Publishing House, Pune, Maharashtra.
3. Das, H.C. and Yadav, A. K. 2018. *Advances in Organic Production of Fruit Crops.* Westville Publishing House, New Delhi.
4. Deshpande, M.S. 2003. *Organic Farming with respect to Cosmic Farming*. Mrs. Pushpa Mohan Deshpandey, Kolhapur, Maharashtra.
5. Deshpande, W. R. 2009. *Basics of Organic Farming*. All India Biodynamic and Organic Farming Association, Indore. M.P.
6. Gaur, A.C., Neblakantan, S. and Dargan, K.S. 1984. *Organic Manures*. ICAR, New Delhi
7. Lampkin, N. and Ipswich, S. 1990. *Organic Farming*. Farming Press. London, UK.
8. Lind, K., Lafer, G., Schloffer, K., Innershofer, G. And Meister, H. 2003. *Organic Fruit Growing*. CAB International
9. Palaniappan, S.P. and Annadurai, K. 2008. *Organic Farming- Theory and Practice*. Scientific Publishers, Jodhpur.
10. Palekar, S. 2004. *The Technique of Spiritual Farming*. Chandra Smaritee, Sai Nagar, Amrawati, Maharashtra.
11. Proctor, P. 2008. *Biodynamic Farming and Gardening*. Other India Press, Mapusa, Goa.
12. Ram, R.A. and Pathak, R.K. 2017. *Bioenhancers*. Lap Lambert Academic Publishing, A.P.


## FSC 531 MINOR FRUIT PRODUCTION 3(2+1)

**WHY THIS COURSE?**

Apart from commercially grown fruits, several other fruits in spite of being rich in nutrients and potential future crops, remains neglected/ underexploited. The hardy nature coupled with the possibility of diversification (newly domesticated crops) further adds to their importance. The course outlines the efforts made in standardizing agro-techniques for propagation and cultivation besides know-how on their nutraceutical value and other uses.

**AIM OF THIS COURSE**

To import basic knowledge underexploited minor fruit crops.

The course is structured as under:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | Occurrence, Adoption and General Account |
| 2. | Agro-Techniques | Propagation and Cultural Practices |
| 3. | Marketing and utilization | Post-Harvest Management |

**COURSE OUTCOMES**

On successful completion of the course, the students are expected to know about

- Various minor fruits hitherto neglected and their commercial value
- Efforts made to domesticate minor fruits and standardization of agro-techniques.
- Their utilization in processing industry.

**THEORY**

**Block 1: Introduction**

**UNIT-I:** Occurrence, Adoption and General Account: Importance – occurrence and distribution, climate adaptation in fragile ecosystem and wastelands.

**Block 2: Agro-Techniques**

**UNIT-I:** Propagation and Cultural Practices: Traditional cultural practices and recent development in agro-techniques; propagation, botany-floral biology, growth patterns, mode of pollination, fruit set, ripening, fruit quality.

**Block 3: Marketing and Utilization**

**UNIT-I:** Post-Harvest Management: Post harvest management, marketing; minor fruit crops in terms of medicinal and antioxidant values; their uses for edible purpose and in processing industry

**CROPS:** Bael, chironji, fig, passion fruit, jamun, phalsa, karonda, woodapple, Cactus pear, khejri, kair, pilu, lasoda, loquat, tamarind, dragon fruit, monkey jack, mahua, khirni, amra, kokum, cape gooseberry, kaphal, persimmon, pistachio, sea buckthorn, hazel nut and Other minor fruits of regional importance

**PRACTICAL**

1. Visits to institutes located in the hot and cold arid regions of the country (2)
2. Identification of minor fruits plants/cultivars (2)
3. Collection of leaves and preparation of herbarium (1)
4. Allelopathic studies (2)
5. Generating know-how on reproductive biology of minor fruits (4)
6. Fruit quality attributes and biochemical analysis (3)
7. Project formulation for establishing commercial orchards in fragile ecosystems (1)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**


1. Ghosh, S. N., Singh, A. and Thakur, A. 2017. *Underutilized Fruit Crops: Importance and Cultivation.* Jaya Publication House, New Delhi.
2. Krishna, H. and Sharma, R.R., 2017. *Fruit Production: Minor Fruits*. Daya Publishing House, New Delhi
3. Mazumdar, B. C. 2014. *Minor Fruit Crops of India: Tropical and Subtropical*. Daya Publication House, New Delhi
4. Nath, V., Kumar, D., Pandey, V. and Pandey, D., 2008. *Fruits for the Future*. Satish Serial Publishing House, New Delhi.
5. Pareek, O. P., Sharma, S. and Arora, R. K., 2007. *Underutilized Edible Fruits and Nuts*. IPGRI, Rome.
6. Peter, K.V., 2010. *Underutilized and Underexploited Horticultural Crops*. NIPA, New Delhi.
7. Rana, J. C. and Verma, V. D. 2011. *Genetic Resources of Temperate Minor Fruit (Indigenous and Exotic).* NBPGR, New Delhi.
8. Saroj, P. L. and Awasthi, O. P., 2005. *Advances in Arid Horticulture. Vol. II: Production Technology of Arid and Semiarid Fruits.* IBDC, Lucknow.
9. Saroj, P. L., Dhandar, D. G. and Vashishta, B.B. 2004. *Advances in Arid Horticulture*, Vol.-1 *Present Status*. IBDC, Lucknow.
10. Singh et al., 2011. *Jamun*. ICAR, New Delhi.


## FSC 532 EXPORT ORIENTED FRUIT PRODUCTION 3(2+1)

**WHY THIS COURSE?**

India is a top ranking country in production of fruit crops especially with respect mangoes, bananas, and grapes. WTO regime opens new vistas for exploring export opportunities of different fruit commodities. Already, India export mangoes, litchi, grapes, walnuts, apples *etc.* and there lies a huge potential in this sector. As such a course has been developed to highlights government policies, standards, infrastructural development and export potential vis-à-vis international scenario.

**AIM OF THIS COURSE**

To acquaints with the national and international standards and export potential of fruit crops
The course is organised as under:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | Statistics and World Trade |
| 2. | Regulations | Policies, Norms and Standards |
| 3. | Quality Assurance | Infrastructure and Plant Material |

**COURSE OUTCOMES:** Consequent upon successful completion of the course, the students are expected to have learnt about

1. National and international trade scenario of fruit crops
2. Set norms and standards for export of fruit crops

3. Requisite infrastructure and growing practices meeting export standards

**THEORY**

**Block 1: Introduction**

**UNIT-I:** Statistics and World Trade: National and international fruit export and import scenario and trends; Statistics and India's position and potentiality in world trade; export promotion zones in India. Government Policies.

**Block 2: Regulations**

**UNIT-I:** Policies, Norms and Standards: Scope, produce specifications, quality and safety standards for export of fruits viz., mango, banana, grape, litchi, pomegranate, cashewnut, walnut, apple and other important fruits. Processed and value-added products, post-harvest management for export including packaging and cool chain; HACCP, *Codex alimentarius*, ISO certification; WTO and its implications, sanitary and phyto-sanitary measures.

**Block 3: Quality Assurance**

**UNIT-I:** Infrastructure and Plant Material: Quality fruit production under protected environment; different types of structures– Automated greenhouses, glasshouse, shade net, poly tunnels- Design and development of low cost greenhouse structures. Seed and planting material; meeting export standards, implications of plant variety protection – patent regimes.

**PRACTICAL**

1. Export promotion zones and export scenario of fresh fruits and their products (1)
2. Practical exercises on quality standards of fruits for export purpose (2)
3. Quality standards of planting material and seeds (2)
4. Hi-tech nursery in fruits (1)
5. Practicals on ISO specifications and HACCP for export of fruits (3)
6. Sanitary and phyto-sanitary measures during export of horticultural produce (2)
7. Post-harvest management chain of horticultural produce for exports (2)
8. Visit to export oriented units/agencies like APEDA, NHB, *etc*.

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**


1. Chadha, K.L. 1995. *Advances in Horticulture*. Vol. XII. Malhotra Publ. House, New Delhi.
2. Chetan, G.F. 2015. *Export Prospects of Fruits and Vegetables from India: A study of Export market in EU. A project report.* Anand Agricultural University, Anand, Gujarat.
3. Dattatreylul, M. 1997. *Export potential of Fruits, Vegetables and Flowers from India*. NABARD, Mumbai.
4. http://apeda.gov.in, http://nhb.gov.in, http://indiastat.com
5. Islam, C.N. 1990. *Horticultural Export of Developing Countries: Past Preferences, Future Prospects and Policies*. International Institute of Food Policy Research, USA.


## FSC 533 CLIMATE CHANGE AND FRUIT CROPS 1(1+0)

**WHY THIS COURSE?**

In the changing climatic scenario, the fruit crops get affected adversely due to one or more unfavourable environmental factors. Shifting of temperate fruits to higher altitudes due to insufficient chilling, occurrence of drought and frost in warmer areas are notable examples. In order to educate on extent of damage and strategies to mitigate the effect of climate change, a course has been formulated.

**AIM OF THIS COURSE**

To understand the impact of climate change and its management in fruit production.
The course is structured as under:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | General Aspects | Introduction, Global Warming and Climatic Variability |
| 2. | Climate Change and Management | Impact Assessment and Mitigation |
| 3. | Case Studies | Response to Climate Change |

**COURSE OUTCOMES**

After the successful completion of the course, the students are expected to have learnt
1. Nature and extent of altered behaviour or damage due to climate change
2. Methods to assess the adverse effects
3. Approaches to mitigate the effect due to climatic variability

**THEORY**

**Block 1: General Aspects**

**UNIT-I:** Introduction, Global Warming and Climatic Variability: Introduction to climate change. Factors directly affecting climate change. Global warming, effect of climate change on spatio-temporal patterns of temperature and rainfall, concentrations of greenhouse gasses in atmosphere. pollution levels such as tropospheric ozone, change in climatic variability and extreme events.

**Block 2: Climate Change and Management**

**UNIT-I:** Impact Assessment and Mitigation: Sensors for recording climatic parameters, plants response to the climate changes, premature bloom, marginally overwintering or inadequate winter chilling hours, longer growing seasons and shifts in plant hardiness for fruit crops.

Climate mitigation measures through crop management- use of tolerant rootstocks and varieties, mulching- use of plastic- windbreak- spectral changes- protection from frost and heat waves. Climate management in greenhouse- heating - vents - CO2 injection - screens - artificial light. Impact of climate changes on invasive insect, disease, weed, fruit yield, quality and sustainability. Climate management for control of pests, diseases, quality, elongation of growth and other plant processes- closed production systems.

**Block 3: Case Studies**

**UNIT-I:** Response to Climate Change: Case studies– responses of fruit trees to climatic variability *vis-a-vis* tolerance and adaptation; role of fruit tree in carbon sequestration.

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. Dhillon, W.S. and Aulakh, P.S. 2011. *Impact of Climate Change in Fruit Production.* Narendra Publishing House, New Delhi.
2. Peter, K.V. 2008. *Basics in Horticulture*. New India Publishing Agency, New Delhi.
3. Ramirez, F. and Kallarackal, J. 2015. *Responses of Fruit Trees to Global Climate Change.* Springer- Verlag.
4. Rao, G.S.L.H.V. 2008. *Agricultural Meteorology*. Prentice Hall, New Delhi.
5. Rao, G.S.L.H.V., Rao, G.G.S.N., Rao, V.U.M. and Ramakrishnan, Y.S. 2008. *Climate Change and Agriculture over India.* ICAR, New Delhi.
6. Schafeer, B. and Anderson, P. 1994. *Handbook of Environmental Physiology of Fruit Crops.* Vol. 1 & 2. CRC Press. USA.

# COURSE CONTENTS: Ph.D. FRUIT SCIENCE

## FSC 611 INNOVATIVE APPROACHES IN FRUIT BREEDING 3(3+0)

**WHY THIS COURSE?**

Modern day fruit culture witnesses rapid changes in production technologies and market trends. Ever changing environment and consumer preferences warrant constant development and adoption of genetically improved varieties. There is more thrust on novelty and distinctness in view of ever increasing competition with enhanced emphasis on tailor made and trait specific designer varieties and rootstocks. The course is thus designed to integrate updated information on inherent breeding systems and innovative gene manipulation technologies enhancing breeding efficiency.

**AIM OF THIS COURSE**

To update knowledge on current trends and innovative approaches in fruit breeding.
The structural organisation of the course is as under:-

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | Current Trends and Status |
| 2. | Genetic Mechanisms | Inheritance Patterns and Breeding Systems |
| 3. | Breeding for Specific Traits | Plant Architecture, Stress Tolerance and Fruit Quality |
| 4. | Fast- Track Breeding | Transgenics, Markers and Genomics |

**COURSE OUTCOMES**

On successful completion of the course, the students are expected to

1. Develop updated knowledge on current breeding objectives and trends
2. Equip with information on innovative approaches enhancing breeding efficiency

**THEORY**

**Block 1: Introduction**

**UNIT-I:** Current Trends and Status: Modern trends in fruit breeding –with major emphasis on precocity, low tree volume, suitability for mechanization, health benefits *etc*.

**Block 2: Genetic Mechanisms**

**UNIT**-I: Inheritance Patterns and Breeding Systems: Genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits.

**Block 3: Breeding for Specific Traits**

**UNIT-I:** Plant Architecture, Stress Tolerance and Fruit Quality: Recent advances in crop improvement efforts- wider adaptation, plant architecture, amenability to mechanization, fruit quality attributes, stress tolerance, crop specific traits ; use of apomixis, gene introgression and wide hybridization ( alien genes).

**Block 4: Fast- Track Breeding**

**UNIT-I:** Transgenics, Markers and Genomics: Molecular and transgenic approaches in improvement of selected fruit crops; fast track breeding– marker assisted selection and breeding (MAS and MAB), use of genomics and gene editing technologies.

**CROPS:** Mango, banana, guava, papaya, Citrus, grapes, pomegranate, litchi, apple, pear, strawberry, kiwifruit, plums, peaches, apricot, cherries, nectarines, nut crops

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**


1. Al-Khayari, J., Jain, S.N. and Johnson, D.V. 2018. *Advances in Plant Breeding Strategies*. Vol. *3: Fruits*. Springer.
2. Badenes, S. and Byrne, D.H. 2012. *Fruit Breeding*. Springer.

3. Hancock, J. F. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. Springer
4. Kole, C. and Abbott, A. G. 2012. *Genetics, Genomics and Breeding of Stone Fruits*. CRC
5. Kole, C. 2011. *Wild Crops Relatives: Genomics and Breeding Resources: Tropical and Subtropical Fruits*. Springer-Verlag.
6. Kole, C. 2011. *Wild Crops Relatives: Genomics and Breeding Resource: Temperate Fruits*. Springer -Verlag.
7. Jain, S.N. and Priyadarshan, P.M. 2009. *Breeding Plantation and Tree Crops: Tropical Species; Temperate Species*. Springer -Verlag.
8. Janick, J. and Moore, J.N., 1996. *Fruit Breeding*. Vols. I-III. John Wiley & Sons, USA.
9. Orton, T. 2019. *Methods in Fruit Breeding*. Elsevier.
10. Singh, S.K., Patel, V.B., Goswami, A.K., Jaiprakash and Chavlesh Kumar.2019. *Breeding of Perennial Horticultural Crops*. Biotech Books. Delhi.

## FSC 612 MODERN TRENDS IN FRUIT PRODUCTION 3(3+0)

**WHY THIS COURSE?**

Recent technological developments in propagation and cultural practices paves the way to grow fruit crops in an intensive and mechanised mode. As such a course has been developed to provide latest knowledge and updated account of modern production systems enhancing overall productivity.

**AIM OF THIS COURSE**

To keep abreast with latest developments and trends in production technologies of tropical, subtropical and temperate fruits.

The course structure is as follows:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | General Concepts and Current Scenario |
| 2. | Advanced Technologies | Propagation, Planting Systems and Crop Regulation |
| 3. | Management Practices | Overcoming Stress and Integrated Approaches |

**COURSE OUTCOMES**

After the successful completion of the course, the students would have updated knowledge on current trends in fruit production.

**Block 1: Introduction**

**UNIT**-I: General Concepts and Current Scenario: National and International scenario, national problems.

**Block 2: Advanced Technologies**

**UNIT-I:** Propagation, Planting Systems and Crop Regulation: Recent advances in propagation - root stocks, planting systems, High density planting, crop modeling, Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation.

**Block 3: Management Practices**

**UNIT**-I: Overcoming Stress and Integrated Approaches: Effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Physiological disorders, Total quality management (TQM)-Current topics.

**CROPS:** Mango, Banana, Grapes, Citrus, Papaya, Litchi, Guava, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherry, Almond, Walnut, Pecan, Strawberry, Kiwifruit

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**


1. Bartholomew, D.P., Paull, R.E. and Rohrbach, K.G. eds., 2002. *The Pineapple: Botany, Production and Uses*. CAB International.
2. Bose, T.K, Mitra, S.K. and Sanyol, D., Eds., 2002. *Fruits of India– Tropical and Sub- Tropical.* 3rd Ed. Vols. I, II. Naya Udyog, Kolkata, India.
3. Dhillon, W.S. and Bhatt, Z. A., 2011. *Fruit Tree Physiology*. Narendra Publishing House, New Delhi.
4. Dhillon, W.S., 2013. *Fruit Production in India*. Narendra Publishing House, New Delhi.
5. Gowen, S., 1995. *Bananas and Plantains*. Chapman & Hall Publication, US.
6. Litz, R.E. ed., 2009. *The Mango: Botany, Production and Uses*. CAB International.
7. Peter, K. V. 2016. *Innovations in Horticulture*. NIPA, New Delhi.
8. Robinson, J.C. and Saúco, V.G., 2010. *Bananas and Plantains* (Vol. 19). CAB International.
9. Samson, J.A., 1980. *Tropical Fruits*. Longman, USA.
10. Sharma, R.R. and Krishna, H. 2014. *Fruit Production: Major Fruits*. Daya Publishing House, Delhi.
11. Singh, S., Shivankar, V.J., Srivastava, A.K. and Singh, I.P. 2004. *Advances in Citriculture*. Jagmander Book Agency, New Delhi.
12. Stover, R.H. and Simmonds, N.W. 1991. *Bananas*. Longman, USA
13. Chadha, K.L., Ahmed, N., Singh, S.K., Kalia P. 2016. *Temperate Fruits and Nuts- Way Forward for Enhancing Production and Quality.* Daya Publishing House, New Delhi
14. Childers, N. F., Morris, J. R. and Sibbett, G. S. 1995. *Modern Fruit Science: Orchard and Small Fruit Culture.* Horticultural Publications, USA.
15. Erez, A. 2013. *Temperate Fruit Crops in Warm Climates*. Springer Science.
16. Jackson, D., Thiele, G., Looney, N. E. and Morley-Bunker, M. 2011. *Temperate and Subtropical Fruit Production.* CAB International
17. Ryugo, K. 1998. *Fruit Culture: Its Science and Art*. John Wiley & Sons, USA.
18. Tromp, J., Webster, A. S. and Wertheim, S. J. 2005. *Fundamentals of Temperate Zone Tree Fruit Production*. Backhuys Publishers, Lieden, The Netherlands.
19. Westwood, M. N. 2009. *Temperate Zone Pomology: Physiology and Culture*. 3rd Edn. Timber Press, USA.


## FSC 621 ABIOTIC STRESS MANAGEMENT IN FRUIT CROPS 3(2+1)

**WHY THIS COURSE?**

Low soil fertility coupled with unpredictable and unfavourable environments often result in stress conditions. Non-availability of optimum level of inputs and congenial weather necessitates the development of suitable management practices to overcome various abiotic stresses. Hence a course is customized.

**AIM OF THIS COURSE**

To updates knowledge on recent trends in management of abiotic stresses in fruit crops. The course is organised as follows:-

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | Basic Aspects and Principles |
| 2. | Stress Impact | Assessment, Physiology and Performance |
| 3. | Stress Management | Mitigation Measures and Conservation Practices |

**COURSE OUTCOMES**

On successful completion of the course, the students are expected to generate know-how on

1. Various types of abiotic stresses and their effects
2. Physiological processes underlying abiotic stresses
3. Management and conservation practices to overcome stress

**THEORY**

**Block 1: Introduction**

**UNIT-I:** Basic Aspects and Principles: Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, *etc.*).Pollution - increased level of CO2, industrial wastes, impact of stress in fruit crop production, stress indices, physiological and biochemical factors associated with stress, fruit crops suitable for different stress situations.

**Block 2: Stress Impact**

**UNIT-I:** Assessment, Physiology and Performance: Crop modeling for stress situations, cropping systems, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stresses and their impact on crop growth and productivity.

**Block 3: Stress Management**

**UNIT-I:** Mitigation Measures and Conservation Practices: Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers. Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, stability and sustainability indices.

**PRACTICAL**

1. Seed treatment /hardening practices (2)
2. Container seedling production (2)
3. Analysis of soil moisture estimates (FC, ASM, PWP) (1)
4. Analysis of plant stress factors, RWC, chlorophyll fluorescence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate *etc.* under varied stress situations (5)
5. Biological efficiencies, WUE, solar energy conversion and efficiency (2)
6. Crop growth sustainability indices and economics of stress management (2)
7. Visit to orchards and watershed locations (2)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. Blumm, A. 1988. *Plant Breeding for Stress Environments*. CRC Publication, USA.
2. Christiansen, M.N. and Lewis, C.F. 1982. *Breeding Plants for Less Favourable Environments*. Wiley International Science, USA.
3. Kanayama, Y. And Kochetor. 2015. *Abiotic Stress Biology in Horticultural Plants*. Springer.
4. Kramer, P.J., 1980. *Drought Stress and the Origin of Adaptation. In: Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons, USA.
5. Maloo, S.R. 2003. *Abiotic Stress and Crop Productivity*. Agrotech Publ. Academy, India.
6. Nickell, L.G. 1983. *Plant Growth Regulating Chemicals*. CRC Publication, USA.
7. Rao. N.K.S., Shivashankar, K.S. and Laxman, R.H. 2016. *Abiotic Stress Physiology of Horticultural Crops.* Springer.
8. Turner, N.C. and Kramer, P.J. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons, USA.

## FSC 622 RECENT DEVELOPMENTS IN GROWTH REGULATION 3(3+0)

**WHY THIS COURSE?**

Technological advancements have resulted in deeper understanding of growth and developmental processes in plants. There is equal and just need to apply these in fruit crops for harnessing maximum benefits in term of yield and quality. So a course has been designed to provide latest information on physiological and biochemical aspects of growth and development.

**AIM OF THIS COURSE**

To develop updates on recent advances in growth regulation of fruit crops.
Structure of the course is as under:-

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | Current Concepts and Principles |
| 2. | Growth Substances | Phytohormones and Growth Regulators |
| 3. | Growth and Development | Regulation of Developmental Processes |

**COURSE OUTCOMES**

After the successful completion of the course, the students would have
1. Complete understanding of growth dynamics in various fruit crops
2. Know-how on manipulation of growth and development processes.

**THEORY**

**Block 1: Introduction**

**UNIT-I:** Current Concepts and Principles: Eco-physiological influences on growth and development of fruit crops-flowering, fruit set- Crop load and assimilate partitioning and distribution.

**Block 2: Growth Substances**

**UNIT-I:** Phytohormones and Growth Regulators: Root and canopy regulation, study of plant growth regulators in fruit culture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants. Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards.

**Block 3: Growth and Development**

**UNIT-I:** Regulation of Developmental Processes: Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production.

Flower drop and thinning, fruit-set and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, molecular approaches in crop growth regulation- current topics.

**TEACHING METHODS/ACTIVITIES**

- Class room Lectures
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. Bhatnagar, P. 2017. *Physiology of Growth and Development of Horticultural Crops*. Agrobios (India).
2. Buchanan, B., Gruiessam, W. and Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*. John Wiley & Sons, US.
3. Fosket, D.E. 1994. *Plant Growth and Development: A Molecular Approach*. Academic Press, USA.
4. Leopold, A.C and Kriedermann, P.E., 1985. *Plant Growth and Development.* 3rd Ed. McGraw-Hill, US.
5. Richard N. Arteca, 1995. *Plant Growth Substances– Principles and Applications.* Chapman & Hall, USA.
6. Roberts, J., Downs, S. and Parker, P., 2002. *Plant Growth Development. In: Plants* (I. Ridge, Ed.), Oxford University Press.
7. Salisbury, F.B. and Ross, C.W., 1992. *Plant Physiology*. 4th Ed. Wadsworth Publication.

## FSC 623 ARID AND DRYLAND FRUIT PRODUCTION 2(2+0)

**WHY THIS COURSE?**

Arid and dryland regions are known for growing an array of delicious and nutritious fruits (e.g. date palm, aonla, ber *etc.*). Over the years, notable progress has been made in respect of domestication and technological advancements. Thus a course has been developed.

**AIM OF THIS COURSE**

To keep abreast with latest developments and trends in production technology of arid and dryland fruit crops.

The course is organised as under:-

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | General Concepts and Current Scenario |
| 2. | Advanced Technologies | Propagation, Planting Systems and Crop Regulation |
| 3. | Management Practices | Stress Mitigation and Integrated Approaches |

**COURSE OUTCOMES**

Consequent upon successful completion of the course, the students are expected to learnt about

1. Fruit crops adopting to arid and drylands and their features
2. Specific cultivation and management practices

**THEORY**

**Block 1: Introduction**

**UNIT-I:** General Concepts and Current Scenario: Characteristics features and major constraints of the arid and dryland region, distinguishing features of the fruit species trees for adaptation in adapting to the region, nutritional and pharmaceutical importance, national problems.

**Block 2: Advanced Technologies**

**UNIT-I:** Propagation, Planting Systems and Crop Regulation: Recent advances in propagation - root stocks, planting systems, High density planting, crop modeling, Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation, effects on physiology and development, influence of stress factors.

**Block 3: Management Practices**

**UNIT-I:** Stress Mitigation and Integrated Approaches: Strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, total quality management (TQM) - Current topics.

**CROPS:** Aonla, Annonas, ber, bael, jamun, date palm, cactus pear, khejri, kair, pilu, lasoda, manila, tamarind, monkey jack, mahua, khirni, amra, sea buckthorn, chilgoza, cafel, rhododendron, box myrtle, chironji, phalsa, karonda, woodapple, paniala and other minor fruits of regional importance.

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. Krishna, H. and Sharma, R.R. 2017. *Fruit Production- Minor Fruits.* Daya Publishing House, Delhi.
2. Hiwale, S. 2015. *Sustainable Horticulture in Semiarid Drylands*. Springer.
3. More, T. A. Singh, R. S. Bhargava, R. and Sharma, B. D. 2012. *Arid Horticulture for Nutrition and Livelihood.* Agrotech Publishing Academy, Udaipur (Rajasthan).
4. Pareek, O. P., Sharma, S. and Arora, R. K. 2007. *Underutilized Edible Fruits and Nuts*. IPGRI, Rome.
5. Peter, K.V. 2010. *Underutilized and Underexploited Horticultural Crops*. NIPA, N. Delhi.
6. Saroj, P. L., Dhandar, D. G. and Vashishta, B. B. 2004. *Advances in Arid Horticulture, Vol.-1 Present Status*. IBDC, Lucknow.
7. Saroj, P. L. and Awasthi, O. P. 2005. *Advances in Arid Horticulture, Vol: II: Production Technology of Arid and Semiarid Fruits*. IBDC, Lucknow.
8. Sontakke, M. B. 2014. *Production and Management of Fruit crops in Arid/ Drylands*. Agrotech Publishing Academy, Udaipur (Rajasthan).

## FSC 624 ADVANCED LABORATORY TECHNIQUES 3(1+2)

**WHY THIS COURSE?**

Accurate quality analysis of edible fruit commodities warrants stringent measurement protocols besides requisite instruments/ tools and laboratory facilities. Consequently, a specialised course is designed for imparting basic and applied training on physical and biochemical assessment of the horticultural produce.

**AIM OF THIS COURSE**

To familiarize with the laboratory techniques for analysis of fruit crops.
The organisation of the course is as under:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | General Aspects | Safety Measures and Laboratory Maintenance |
| 2. | Qualitative and Quantitative Analysis | Destructive and Non-destructive Analysis Methods<br>Chromatographic and microscopic Sensory Analysis |

**COURSE OUTCOMES**

The students would be expected to develop skills and expertise on
1. Upkeep of laboratories and handling of research instruments
2. Principles and methods of various analysis

**THEORY**

**Block 1: General Aspects**

**UNIT-I:** Safety Measures and Laboratory Maintenance: Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.

**Block 2: Qualitative and Quantitative Analysis**

**UNIT-I:** Destructive and Non-destructive Analysis Methods: Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops.

**UNIT-II:** Chromatographic and Microscopic Analysis: Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in horticultural produce.

**UNIT-III:** Sensory Analysis: Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.

**PRACTICAL**

1. Determination of moisture, relative water content and physiological loss in weight (2)
2. Determination of biochemical components in horticultural produce (3)
3. Calibration and standardization of instruments (1)
4. Textural properties of harvested produce (1)
5. Determination of starch index (SI) (1)
6. Specific gravity for determination of maturity assessment, and pH of produce (1)
7. Detection of adulterations in fresh as well as processed products (2)
8. Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch (2)
9. Estimation of rate of ethylene evolution using gas chromatograph (GC) (2)
10. Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, *etc.*) (2)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations

- Assignments

**SUGGESTED READINGS**


1. AOAC International. 2003. *Official Methods of Analysis of AOAC International*. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities, USA.
2. Clifton, M. and Pomeranz, Y. 1988. *Food Analysis-Laboratory Experiments*. AVI Publ., USA.
3. Linskens, H. F. and Jackson, J. F. 1995. *Fruit Analysis*. Springer.
4. Leo, M.L. 2004. *Handbook of Food Analysis*. 2nd Ed. Vols. I-III, USA.
5. Pomrenz, Y. and Meloan, C.E. 1996. *Food Analysis- Theory & Practice*. CBS, USA.
6. Ranganna, S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. 2nd Ed. Tata-McGraw-Hill, New Delhi.
7. Thompson, A.K. 1995. *Post-Harvest Technology of Fruits and Vegetables*. Blackwell Sciences. USA.


## FSC 625 BIODIVERSITY AND CONSERVATION OF FRUIT CROPS 3(2+1)

**WHY THIS COURSE?**

The availability of pertinent gene pool is of utmost importance to mitigate adverse climate and to counter diseases and pests. In addition, specific gene sources (germplasm) would always be a necessity to develop superior genotypes. Considering the importance of conserving biodiversity in fruit crops for future use, the course has been designed.

**AIM OF THIS COURSE**

To understand the status and magnitude of biodiversity and strategies in germplasm conservation of fruit crops.

The course is organised as follows:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | General Aspects | Issues, Goals and Current Status |
| 2. | Germplasm Conservation | Collection, Maintenance and Characterization |
| 3. | Regulatory Horticulture | Germplasm Exchange, Quarantine and Intellectual Property Rights |

**COURSE OUTCOMES**

The student would be expected to learn about the significance of germplasm and various strategies to conserve it in the present context.

**THEORY**

**Block 1: GENERAL ASPECTS**

**UNIT-I:** Issues, Goals and Current Status: Biodiversity and conservation; issues and goalsneeds and challenges; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/database of fruit crops in India

**Block 2: Germplasm Conservation**

**UNIT-I:** Collection, Maintenance and Characterization: Exploration and collection of germplasm; sampling frequencies ; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- *in situ* and *ex situ* strategies, on farm conservation; problem of recalcitrancy- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

**Block 3: Regulatory Horticulture**

**UNIT-I:** Germplasm Exchange, Quarantine and Intellectual Property Rights: Regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV&FR Act.

GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India.

**PRACTICAL**

1. Documentation of germplasm- maintenance of passport data and other records of accessions (2)

2. Field exploration trips and sampling procedures (2)
3. Exercise on *ex situ* conservation – cold storage, pollen/seed storage (2)
4. Cryopreservation (2)
5. Visits to National Gene Bank and other centres of PGR activities (2)
6. Detection of genetic constitution of germplasm (2)
7. Germplasm characterization using a standardised DUS test protocol (2)
8. Special tests with biochemical and molecular markers (2)

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Laboratory / Field Practicals
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. Dhillon, B. S., Tyagi, R. K., Lal, A. and Saxena, S. 2004. *Plant Genetic Resource Management– Horticultural Crops*. Narosa Publishing House, New Delhi.
2. Engles, J. M., Ramanath R, V., Brown, A. H. D. and Jackson, M. T. 2002. *Managing Plant Genetic Resources*. CABI, Wallingford, UK.
3. Frankel, O.H. and Hawkes, J.G., 1975. *Crop Genetic Resources for Today and Tomorrow.* Cambridge University Press, USA.
4. Hancock, J. 2012. *Plant Evolution and the Origin of Crops Species*. CAB International.
5. Jackson, M., Ford-Lloyd, B. and Parry, M. 2014. *Plant Genetic Resources and Climate Change*. CABI, Wallingford, UK
6. Moore, J. N. and Ballington Jr, J. R. 1991. *Genetic Resources of Temperate Fruit and Nut Crops*. ISHS, Belgium.
7. Peter, K.V.2008. *Biodiversity of Horticultural Crops*. Vol. II. Daya Publ. House, Delhi.
8. Peter, K.V. 2011. *Biodiversity in Horticultural Crops*. Vol. III. Daya Publ. House, Delhi.
9. Rana, J. C. and Verma, V. D. 2011. *Genetic Resources of Temperate Minor Fruits (Indigenous and Exotic).* NBPGR, New Delhi.
10. Rajasekharan, P.E., Rao, V and Ramanatha, V. 2019. *Conservation and Utilization of Horticultural Genetic Resources*. Springer.
11. Sthapit, B., et al. 2016. *Tropical Fruit Tree Diversity (Good Practices for in situ and ex situ conservation).* Bioversity International. Routledge, Taylor and Francis Group.
12. Virchow, D., 2012. *Conservation of Genetic Resources*. Springer Verlag, Berlin.

## FSC 626 SMART FRUIT PRODUCTION 2(2+0)

**WHY THIS COURSE?**

In the era of automation and mechanization, several recent innovations have direct applications in fruit growing. Thus a need is felt to have course on smart innovations.

**AIM OF THIS COURSE**

To acquire knowledge on hi-tech innovations useful in fruit crops. The course is structure is as under:-

| S. No. | Blocks | Units |
|---|---|---|
| 1. | Introduction | Importance and Overview |
| 2. | Crop Modeling and Forecasting | GIS, Sensors and Wireless System |
| 3. | Nanotechnology | Concepts and Methods |
| 4. | Innovative Approaches | Mechanization, Automation and Robotics |

**COURSE OUTCOMES**

After successful completion of the course, the students are expected to learn about latest innovations in automation, nanotechnology and robotics for realising smart fruit production.

**THEORY**

**Block 1: Introduction**

**UNIT-I**: Importance and Overview: Introduction and importance; concepts and applications of artificial intelligence systems; case studies in horticulture

**Block 2: Crop Modeling and Forecasting**

**UNIT-I:** GIS, Sensors and Wireless Systems: Application of sensors in fruit production, crop monitoring – crop load and stress incidence forecast modules, remote sensing, Geographical Information System (GIS), Differential Geo-Positioning System (DGPS) hi-tech nursery production of fruit crops under protected conditions, ultra modern wireless based drip irrigation network,

**Block 3: Nanotechnology**

**UNIT-I:** Concepts and Methods: Nanotechnology for smart nutrient delivery in fruit farming, concepts and methods, practical utility, nano-fertilizers, nano-herbicides; nano-pesticides

**Block 4: Innovative Approaches**

**UNIT-I:** Mechanization, Automation and Robotics: Production systems amenable to automation and mechanization; automated protected structures (turn-key systems); hydroponics, aeroponics, bioreactors for large scale plant multiplication; Use of drones and robotics in fruit growing– robotic planters, sprayers, shakers, harvesters, stackers *etc*. Visit to Hi-tech facilities.

**TEACHING METHODS / ACTIVITIES**

- Class room Lectures
- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

**SUGGESTED READINGS**

1. Chadha *et al.* 2017. *Doubling Farmers' Incomes through Horticulture*. Daya Publishing House, New Delhi.
2. Chadha *et al.* 2019. *Shaping the Future of Horticulture*. Kruger Brentt Publishers, UK.
3. Hewett, E. W. 2013. *Automation, Mechanization and Robotics in Horticulture. In: Workshop on Emerging Postharvest Technologies*. UC, Davis, USA.
4. http://horticulture.ucdavis.edu- Innovative Technology for Horticultural Department.
5. Prasad, S., Singh, D. and Bhardwaj, R. L. 2012. *Hi-Tech Horticulture.* Agrobios (India).
6. Peter, K. V. 2016. *Innovations in Horticulture*. NIPA, New Delhi.
7. Tyagi, S. 2019. *Hi- Tech Horticulture*. Vols. 1 to 7. NIPA, New Delhi.
8. Zhang, Q. 2017. *Automation in Tree Fruit production– Principles and Practice.* CABI.

# COURSE CONTENTS: M.Sc. (Hort.) PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS

## PSM 511 PRODUCTION OF PLANTATION CROPS 3(2+1)

**WHY THIS COURSE?**

Plantation crops play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers. This course will impart theoretical as well as hands-on experience to the learner on scientific production technology of various plantation crops in Indian perspectives. It will provide comprehensive knowledge in this regard.

**AIM OF THIS COURSE**

The course is designed to provide both basic and applied knowledge on various aspects of production technology of plantation crops grown in India.

**COURSE OUTCOME**

After successful completion of this course, the students are expected to:
1. Develop the technical skill in commercial cultivation of plantation crops
2. Be able to start plantation crop-based enterprises

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Importance of Plantation Crops | 1. Role of plantation crops |
| | | 2. Export potential |
| | | 3. Promotional programmes |
| 2. | Production Technology | 1. Varietal wealth |
| | | 2. Propagation and nursery management |
| | | 3. Agro techniques |
| 3. | Harvest and Post-harvest management | 1. Maturity indices and harvest |
| | | 2. Post-harvest management |

**THEORY**

**Block 1: Importance of Plantation Crops**

**UNIT-I:** ***Role of plantation crops**:* Role of plantation crops in national economy, area production statistics at national and international level, classification, clean development mechanism and carbon sequestration potential of plantation crops

**UNIT-II:** ***Export potential***: Export potential, problems and prospects and IPR issues in plantation crops

**UNIT-III:** ***Promotional programmes**:* Role of commodity boards and directorates in the development programmes of plantation crops

**Block 2: Production Technology**

**UNIT-I:** ***Varietal wealth**:* Botany, taxonomy, species, cultivars and improved varieties in plantation crops

**UNIT-II:** ***Propagation and nursery management**:* Plant multiplication including in vitro multiplication, nursery techniques and nursery management in plantation crops

**UNIT-III:** ***Agro techniques***: Systems of cultivation, cropping systems, multitier cropping, climate and soil requirements, systems of planting, high density planting, nutritional requirements, water requirements, fertigation, moisture conservation, role of growth regulators, macro and micro nutrients, nutrient deficiency symptoms, physiological disorders, shade regulation, weed management, training and pruning, crop regulation, plant protection, management of drought, precision farming.

**Block 3: Harvest and Post-harvest management**

**UNIT-I:** ***Maturity indices and harvest**:* Maturity indices, harvesting methods, harvesting seasons and mechanized harvesting in plantation crops

**UNIT-II:** ***Post harvest management****:* Post harvest handling including primary processing, grading, packaging, storage and benefit cost analysis of plantation crops

**CROPS:** Coconut, Arecanut, Oilpalm, Cashew, Coffee, Tea, Cocoa, Rubber, Palmyrah, Betel vine

**PRACTICAL**

1. Description of botanical and varietal features;
2. Selection of mother palms and seedlings;
3. Nursery techniques;
4. Soil and water conservation measures;
5. Nutrient deficiency symptoms;
6. Manuring practices;
7. Pruning and training methods;
8. Maturity standards;
9. Harvesting;
10. Project preparation for establishing plantations;
11. GAP in plantation crops;
12. Exposure visits to commercial plantations, research institutes.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

**SUGGESTED READINGS**

1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology*. CRC Press
2. Anonymous, 1985. *Rubber and its Cultivation*. The Rubber Board of India.
3. Chopra, V.L. and Peter, K. V. 2005. *Handbook of Industrial Crops*. Panima.
4. Choudappa, P., Anitha, K., Rajesh, M.K., and Ramesh, S.V. 2017. *Biotechnology of Plantation Crops.* Daya Publishing House, New Delhi
5. Choudappa, P., Niral, V., Jerard, B.A. and Samsudeen, K. 2017. Coconut. Daya Publishing House, New Delhi
6. *e-manual on Advances in Cashew Production Technology.* ICAR –Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
7. Harler, C.R. 1963. *The Culture and Marketing of Tea*. Oxford Univ. Press.
8. Joshi, P. 2018. *Text Book on fruit and plantation crops*. Narendra Publishing House, New Delhi
9. Kurian, A. and Peter, K.V. 2007. *Commercial Crops Technolo*gy. New India Publ. Agency.
10. Nair, M.K, BhaskaraRao, E.V.V., Nambia, K.K.N., and Nambiar, M.C. 1979. *Cashew*. CPCRI, Kasaragod.
11. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
12. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
13. Peter, K. V. 2002. *Plantation Crops*. National Book Trust.
14. Pillay, P. N. R. 1980. *Handbook of natural rubber production in India*. Rubber Research Institute, Kottayam. pp.668
15. Pradeepkumar, T., Suma, B., Jyothibhaskar and Satheesan, K.N. 2007. *Management of Horticultural Crops*. Parts I, II. New India Publ. Agency.
16. Ramachandra *et al.* 2018. *Breeding of Spices and Plantation crops*. Narendra Pub. House, New Delhi
17. Ranganathan, V. 1979. *Handbook of Tea Cultivation*. UPASI, Tea Res. Stn. Cinchona.
18. Sera T., Soccol C.R., Pandey A., Roussos S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
19. Sethuraj, M.R. and Mathew, N.T.1992. *Natural Rubber: Biology, Cultivation and Technology* (Developments in Crop Science). Elsevier Science.
20. Sharangi, A.B. and Datta, S. 2015. Value Addition of Horticultural crops: Recent trends and Future directions. SPRINGER; ISBN: 978-81-322-2261-3.
21. Sharangi, A.B. and Acharya, S.K.2008. *Quality management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2

22. Srivastava, H.C, Vatsaya, and Menon, K.K.G. 1986. *Plantation Crops – Opportunities and Constraints*. Oxford and IBH.
23. Thampan, P. K. 1981. *Handbook of Coconut Pal*m. Oxford and IBH.

## PSM 512 PRODUCTION OF SPICE CROPS 3(2+1)

**WHY THIS COURSE?**

Spice crops play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers. This course will impart theoretical as well as hands-on experience to the learner on scientific production technology of various spice crops in Indian perspectives. It will provide comprehensive knowledge in this regard.

**AIM OF THIS COURSE**

The course is designed to provide both basic and applied knowledge on various aspects of production technology of spice crops grown in India.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Importance of Spice Crops | 1. Role of spice crops |
| | | 2. Classification of spice crops |
| 2. | Production Technology | 1. Varietal wealth |
| | | 2. Propagation and nursery management |
| | | 3. Agro techniques |
| 3. | Harvest and Post-harvest management | 1. Maturity indices and harvest |
| | | 2. Post-harvest management |

**COURSE OUTCOME**

After successful completion of this course, the students are expected to:

1. Develop the technical skill in commercial cultivation of spice crops
2. Be able to start spice-based enterprises.

**THEORY**

**Block 1: Importance of spice crops**

**UNIT-1:** *Role of Spice crops:* Introduction, importance of spice crops, pharmaceutical significance, historical accent, present status – national and international, future prospects, role of Spices board and other development agencies

**UNIT-II**: *Classification of spice crops:* Major spices, minor spices, seed spices, tree spices, herbal spices

**Block 2: Production Technology**

**UNIT-I**: *Varietal wealth:* Botany and taxonomy, species, cultivars, commercial varieties/hybrids in spice crops

**UNIT-II**: *Propagation and nursery management:* Seed, vegetative and micro-propagation methods, nursery techniques and nursery management practices

**UNIT-III**: *Agro techniques*: Climatic and soil requirements, site selection, layout, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, plant protection, precision farming, physiological disorders, protected cultivation

**Block 3: Harvest and Post-harvest management**

**UNIT-I**: *Maturity indices and harvest:* Maturity indices, harvesting methods, harvesting seasons, mechanized harvesting

**UNIT-II**: *Postharvest management:* Post harvest management including primary processing, grading, packaging and storage, GMP in major spice crops

**CROPS:** Black pepper, small and large Cardamom, Turmeric, Ginger, Garlic, Coriander, Fenugreek, Cumin, Fennel, Ajowain, Saffron, Vanilla, Nutmeg, Clove, Cinnamon, Allspice, Tamarind, Garcinia

**PRACTICAL**

1. Identification of seeds and plants;
2. Botanical description of plant;
3. Varietal features;
4. Planting material production;
5. Field layout and method of planting;
6. Cultural practices;
7. Harvest maturity, harvesting;
8. Drying, storage, packaging;
9. Primary processing;
10. GAP in spice crops;
11. GMP in spice crops;
12. Short term experiments on spice crops;
13. Exposure visits to spice farms, research institutes.

**TEACHING METHODS/ ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

**SUGGESTED READINGS**


1. Agarwal, S., Sastry, E.V.D. and Sharma, R.K. 2001. *Seed Spices: Production, Quality, Export*. Pointer Publ.
2. Arya, P. S. 2003. *Spice Crops of India*. Kalyani.
3. Bose, T.K., Mitra, S.K., Farooqi, S.K. and Sadhu, M.K. (Eds.). 1999. *Tropical Horticulture* .Vol.I. Naya Prokash.
4. Chadha, K.L. and Rethinam, P. (Eds.). 1993. *Advances in Horticulture*. Vols. IX-X. *Plantation Crops and Spices*. Malhotra Publ. House.
5. Gupta, S. (Ed.). *Handbook of Spices and Packaging with Formulae*. Engineers India Research Institute, New Delhi.
6. Kumar, N. A, Khader, P., Rangaswami and Irulappan, I. 2000. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Oxford and IBH.
7. Nybe, E.V, Miniraj, N and Peter, K.V. 2007. *Spices*. New India Publ. Agency.
8. Parthasarthy, V.A, Kandiannan V and Srinivasan V. 2008. *Organic Spices*. NIPA.
9. Peter, K.V. 2001. *Handbook of Herbs and Spice*s. Vol. I-III. Woodhead Pub Co. UK & CRC USA
10. Ponnuswami, V *et al*. 2018. *Medicinal Herbs and herbal cure*. Narendra Pub. House, New Delhi
11. Pruthi, J.S. (Ed.). 1998. *Spices and Condiments*. National Book Trust.
12. Pruthi, J.S. 2001. *Minor Spices and Condiments- Crop Management and Post-Harvest Technology*. ICAR.
13. Purseglove, J.W., Brown, E.G., Green, C.L., and Robbins, S.R. J. (Eds.). 1981. Spices. Vols. I, II. Longman.
14. Ramachandra *et al*. 2018. *Breeding of Spices and Plantation crops*. Narendra Pub. H., New Delhi
15. Ravindran, P.N. 2000. *Black pepper, Piper nigrum*. CRC press
16. Ravindran, P.N. 2002. *Cardamom, the genus Elettaria*. CRC press
17. Ravindran, P.N. 2003. *Cinnamon and cassia*. CRC press
18. Ravindran, P.N. 2004. *Ginger, the genus Zingiber*. CRC press
19. Ravindran, P.N. 2007. *Turmeric, the genus curcuma*. CRC press
20. Ravindran, P.N. 2017. *The Encyclopedia of Herbs and Spices*. CABI
21. Shanmugavelu, K.G, Kumar, N., and Peter, K.V. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.
22. Sharangi, A.B, Datta, S. and Deb, P. 2018. *Spices "Agrotechniques for quality produce*". Apple Academic Press (Tyler and Francis Groups), New Jersey, USA
23. Sharangi, A.B. 2018. *Indian Spices "The legacy, production and processing of India's treasured export."* Springer Int. publishing AG, Part of Springer Nature 2018, Cham, Switzerland.
24. Sharangi, A.B. and Datta, S. 2015. V*alue Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.

25. Sharangi, A.B. and Acharya, S.K.2008. *Quality management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2
26. Thamburaj, S and Singh, N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*, ICAR.
27. Tiwari, R.S. and Agarwal, A. 2004. *Production Technology of Spices*. IBDC.

## PSM 513 PRODUCTION OF MEDICINAL AND AROMATIC CROPS 3(2+1)

**WHY THIS COURSE?**

Medicinal and aromatic crops play an important role in the national economy of India. These crops also provide health security to all. This course will impart theoretical as well as hands-on experience to the learner on scientific production technology of various medicinal and aromatic crops in Indian perspectives. It will provide comprehensive knowledge in this regard.

**AIM OF THIS COURSE**

To impart comprehensive knowledge on the production technology of important medicinal and aromatic crops

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| | Importance of Medicinal and Aromatic Crops | Classification of medicinal and aromatic crops |
| | | Medicinal plant based industry |
| | | Aromatic plant based industry |
| 2. | Production technology | Varietal wealth |
| | | Propagation and nursery management |
| | | Agro techniques |
| 3. | Harvest and Post-harvest management | Maturity indices and harvest |
| | | Post-harvest management |

**COURSE OUTCOME**

After successful completion of this course, the students are expected to:
1. Develop the technical skill in commercial cultivation of medicinal and aromatic crops
2. Be able to start medicinal and aromatic crop-based enterprises

**THEORY**

**Block 1: Importance of Medicinal and Aromatic Crops**

**UNIT-I**: *Classification of medicinal and aromatic crops*: Importance of medicinal plants, Importance of aromatic plants, Role in national economy, utility sectors of medicinal and aromatic crops, classification of medicinal and aromatic crops, role of institutions, Medicinal Plant Board and NGO's in research and development of medicinal and aromatic crops

**UNIT-II**: *Medicinal and plant based industry:* Indian system of medicine, traditional systems of medicine, tribal medicine, medicinal industry, source of medicinal plants, area, production, export and import of major crops, problems, prospects and challenges, IPR issues

**UNIT-III**: *Aromatic plant based industry*: Essential oils, classification, physical and chemical properties and storage of essential oils. Indian perfumery industry, area, production, export and import status of major aromatic crops, history and advancements, problems, prospects and challenges, IPR issues

**Block 2: Production technology of medicinal and aromatic crops**

**UNIT-I**: *Varietal wealth:* Botany and taxonomy, species, cultivars, commercial varieties/hybrids in medicinal and aromatic crops

**UNIT-II**: *Propagation and nursery management*: Seed, vegetative and micro-propagation methods, nursery techniques and nursery management practices

**UNIT-III**: *Agro techniques*: Climatic and soil requirements, site selection, layout, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, plant protection

**Block 3: Harvest and Post-harvest management**

**UNIT-I**: *Maturity indices and harvest*: Maturity indices, harvesting methods, harvesting seasons in medicinal and aromatic crops

**UNIT-II**: *Postharvest management*: Post harvest management including primary processing, extraction, grading, packaging and storage, GMP in medicinal and aromatic crops

**CROPS:**

A. *Medicinal crops*: Senna, periwinkle, medicinal coleus, aswagandha, glory lily, sarpagandha, Dioscoreasp., Aloe vera, *Andrographis paniculata*, Digitalis, medicinal solanum, isabgol, opium poppy, safedmusli, *Stevia rebaudiana*, *Mucuna pruriens*, *Piper longum*, *Plumbago zeylanica*

B. *Aromatic crops:* Palmarosa, lemongrass, citronella, vetiver, mentha, patchouli, sweet flag, jasmine, geranium, artemisia, lavender, *Ocimum sp.*, eucalyptus, sandal

**PRACTICAL**

1. Description of botanical and varietal features;
2. Nursery techniques;
3. Lay out and planting;
4. Manuring practices;
5. Maturity standards;
6. Harvesting;
7. Primary processing;
8. Extraction of oils;
9. Herbarium preparation;
10. Project preparation for establishing herbal gardens;
11. GAP in medicinal and aromatic crops;
12. GMP in medicinal and aromatic crops;
13. Exposure visits to institutes, herbal gardens and industries.

**TEACHING METHODS/ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

**SUGGESTED READINGS**

1. Atal, C.K. and Kapur, B.M. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.
2. Barche, S. 2016. *Production technology of spices, aromatic, medicinal and plantation crops.* New India Publishing Agency, New Delhi
3. Das, K. 2013. *Essential oils and their applications*. New India Publishing Agency, New Delhi
4. Farooqi, A.A. and Sriram, A.H. 2000. *Cultivation Practices for Medicinal and Aromatic Crops*. Orient Longman Publ.
5. Farooqi, A.A, Khan, M.M., and Vasundhara, M. 2001. *Production Technology of Medicinal and Aromatic Crops*. Natural Remedies Pvt. Ltd.
6. Gupta, R.K 2010. *Medicinal and Aromatic plants*. CBS publications
7. Hota, D. 2007. *Bio Active Medicinal Plants*. Gene Tech Books.
8. Jain SK. 2000. *Medicinal Plants*. National Book Trust.
9. Khan, I.A. and Khanum, A. 2001. *Role of Biotechnology in Medicinal and Aromatic Plants*. Vol. IX. Vikaaz Publ.
10. Kurian, A and Asha Sankar, M. 2007. *Medicinal Plants*. Horticulture Science Series, NIPA.
11. Panda, H. 2002. *Medicinal Plants Cultivation and their Uses*. Asia Pacific Business Press.
12. Panda, H. 2005. *Aromatic Plants Cultivation, Processing and Uses*. Asia Pacific Business Press.
13. Ponnuswami *et al.* 2018. *Medicinal Herbs and herbal cure*. Narendra Pub. House, New Delhi
14. Prajapati, S.S., Paero, H., Sharma, A.K. and Kumar, T. 2006. A Handbook of Medicinal Plants. Agro Bios.
15. Ramawat, K.G. and Merillon, J.M. 2003. *BioTechnology– Secondary Metabolites*. Oxford and IBH.
16. Shankar, S.J. 2018. C*omprehensive postharvest technology of flowers, medicinal and aromatic plants*. Narendra Publishing House, New Delhi
17. Skaria, P.B., Samuel, M., Gracy Mathew, Ancy Joseph, Ragina Joseph. 2007. *Aromatic Plants*. New India Publ. Agency.

## PSM 521 BREEDING OF PLANTATION AND SPICE CROPS 3(2+1)

**WHY THIS COURSE?**

Plantation and spice crops play an important role in the national economy of India. For maximizing the production, productivity and quality of plantation and spice crops, fundamental knowledge on breeding methods of the major crops is essential. This course will impart theoretical as well as hands-on experience to the learner on reproductive biology, breeding methods and breeding achievements in various plantation and spice crops

**AIM OF THIS COURSE**

To impart comprehensive knowledge on the principles and practices in the breeding of important plantation and spice crops.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Genetic diversity | Species and cultivar diversity |
| | | Germplasm evaluation |
| 2. | Crop improvement | Breeding objectives |
| | | Breeding methods |
| 3. | Breeding achievements and future thrusts | Breeding achievements |
| | | Future thrusts |

**COURSE OUTCOME:**

After successful completion of this course, the students are expected to:

1. Develop the technical skill in breeding of plantation and spice crops
2. Be able to start plantation and spice crop-based seed production/nursery centres

**THEORY**

**Block 1: Genetic diversity**

**UNIT-I**: *Species and cultivar diversity:* Floral and reproductive biology, cytogenetics, male sterility, incompatibility, wild and cultivated species, popular cultivars

**UNIT-II**: *Germplasm evaluation*: Survey, collection, conservation and evaluation of germplasm

**Block 2: Crop improvement**

**UNIT-I**: *Breeding objectives:* Breeding objectives/goals on the basis of yield, quality, stress tolerance, adaptation

**UNIT-II**: *Breeding methods*: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses

**Block 3: Breeding achievements and future thrusts**

**UNIT-I**: *Breeding achievements*: Breeding achievements in terms of released varieties, parentage, salient features

**UNIT-II**: *Future thrusts*: Molecular breeding and biotechnological approaches, marker assisted selection, bioinformatics, breeding for climate resilience

**CROPS:**

A. *Plantation crops*: Coconut, Arecanut, Cashew, Cocoa, Rubber, Oil palm, Coffee, Tea, Palmyrah, Betel vine

B. *Spice crops*: Black pepper, small and large cardamom, Ginger, Turmeric, Fenugreek, Coriander, Fennel, Cumin, Ajowain, Garlic, Nutmeg, Cinnamon, Clove, Allspice, Garcinia, Tamarind

**PRACTICAL**

1. Characterization and evaluation of germplasm;
2. Floral biology, anthesis; pollen behaviour, fruit set;
3. Practices in hybridization, selfing and crossing techniques;
4. Polyploidy breeding;
5. Mutation breeding;
6. Induction of somaclonal variation and screening the variants;
7. Evaluation of biometrical traits and quality traits;
8. Salient features of improved varieties and cultivars;

9. Screening for biotic and abiotic stresses;
10. Bioinformatics;
11. Exposure visits to research institutes for plantation and spice crops.

**TEACHING METHODS/ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

**SUGGESTED READINGS**


1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology.* CRC Press
2. Anonymous. 1985. *Rubber and its Cultivation*. The Rubber Board of India.
3. Chadha, K.L, Ravindran, P.N and Sahijram, L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.
4. Chadha, K.L. 1998. *Advances in Horticulture*. Vol. IX, X. *Plantation and Spices Crop*s. Malhotra Publishing House, New Delhi.
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6. Chopra, V.L. and Peter, K.V. 2002. *Handbook of Industrial Crop*s. Haworth Press, USA and. Panama International Publ. (Indian Ed.).
7. Choudappa, P., Anitha, K., Rajesh, M.K. and Ramesh, S.V. 2017. *Biotechnology of Plantation Crops.* Daya Publishing House, New Delhi
8. Damodaran, V. K., Vilaschandran, T. and Valsalakumari, P.K.1979. *Research on Cashew in India.* KAU, Trichur.
9. Devi, A.R, Sharangi, A.B, Acharya, S.K. and Mishra, G.C. 2017. *Coriander in Eastern India: The landraces and genetic diversity*. Krishi Sanskriti Publications. New Delhi.
10. *E-manual on Advances in Cashew Production Technology*. ICAR –Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
11. Harver, A.E. 1962. *Modern Coffee Production*. Leonard Hoff.
12. Kumar, N. 2017. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. CBS Publishers
13. Nybe, E.V, Miniraj, N and Peter, K.V. 2007. *Spices*. New India Publishing Agency
14. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
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17. Ponnuswami *et al.* 2018. *Blossom biology of Horticultural crops*. Narendra Pub. H., New Delhi
18. Ponnuswami *et al.* 2018. *Botany of Horticultural crops*. Narendra Publishing House, New Delhi
19. Ponnuswami *et al.* 2018. *Spices*. Narendra Publishing House, New Delhi
20. Raj, P.S. and Vidyachandra, B. 1981. *Review of Work Done on Ca*shew. UAS Research Series No.6, Bangalore.
21. Ramachandra *et al*. 2018. *Breeding of Spices and Plantation Crops*. Narendra Publishing House, New Delhi
22. Ravindran, P.N. 2002. *Cardamom, the genus Elet*taria. CRC press
23. Ravindran, P.N 2003. *Cinnamon and cassia*. CRC press
24. Ravindran, P.N 2004. *Ginger, the genus Zingiber*. CRC press
25. Ravindran, P.N 2007. *Turmeric, the genus Curcuma*. CRC press
26. Ravindran. P.N. 2017. *The Encyclopedia of Herbs and Spic*es. CABI
27. Sera T., Soccol C.R., Pandey A., Roussos S. *Coffee Biotechnology and Qu*ality. Springer, Dordrecht.
28. Sethuraj, M.R. and Mathew, N.T.1992. *Natural Rubber: Biology, Cultivation and Techno*logy (Developments in Crop Science). Elsevier Science.
29. Sharangi, A.B. and Datta, S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions.* SPRINGER; ISBN: 978-81-322-2261-3.
30. Thampan, P.K. 1981. *Handbook of Coconut Palm*. Oxford and IBH.

## PSM 522 BREEDING OF MEDICINAL AND AROMATIC CROPS 2(1+1)

**WHY THIS COURSE?**

Medicinal and aromatic crops play an important role in the national economy of India. For maximizing the production, productivity and quality of medicinal and aromatic crops, fundamental knowledge on breeding methods of the major crops is essential. This course will impart theoretical as well as hands-on experience to the learner on reproductive biology, breeding methods and breeding achievements in various medicinal and aromatic crops.

**AIM OF THIS COURSE**

To impart comprehensive knowledge on the principles and practices in the breeding of important medicinal and aromatic crops.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Genetic diversity | 1. Species and cultivar diversity |
| | | 2. Germplasm evaluation |
| 2. | Crop improvement | 1. Breeding objectives |
| | | 2. Breeding methods |
| 3. | Breeding achievements and future thrusts | 1. Breeding achievements |
| | | 2. Future thrusts |

**COURSE OUTCOME**

After successful completion of this course, the students are expected to:
1. Develop the technical skill in breeding of medicinal and aromatic crops
2. Be able to start medicinal and aromatic crop-based seed production/nursery centres

**THEORY**

**Block 1: Genetic diversity**

**UNIT-I**: *Species and cultivar diversity*: Floral and reproductive biology, cytogenetics, male sterility, incompatibility, wild and cultivated species, popular cultivars

**UNIT-II**: *Germplasm evaluation:* Survey, collection, conservation and evaluation of germplasm, IPR issues

**Block 2: Crop improvement**

**UNIT-I**: *Breeding objectives*: Breeding problems in medicinal and aromatic crops. Genetics of active principles, breeding objectives/goals on the basis of yield, quality, stress tolerance, adaptation

**UNIT-II**: *Breeding methods*: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses

**Block 3: Breeding achievements and future thrusts**

**UNIT-I**: *Breeding achievements*: Breeding achievements in terms of released varieties, parentage, salient features

**UNIT-II**: *Future thrusts*: Molecular breeding and biotechnological approaches, marker assisted selection, bioinformatics, breeding for climate resilience

**CROPS:**

A. *Medicinal crops*: *Cassia angustifolia, Catharanthus roseus, Gloriosa superba, Coleus forskohlii, Stevia rebaudiana, Withania somnifera, Papaver somniferum, Plantago ovata, Chlorophytum sp., Rauvolfia serpentina, Aloe vera, Piper longum, Plumbago zeylanica*

B. *Aromatic crops:* Mint, geranium, patchouli, lemon grass, palmarosa, citronella, vetiver, Artemisia, ocimum, lavender, *Kaempferia galanga*, eucalyptus.

**PRACTICAL**

1. Description of botanical features;
2. Cataloguing of cultivars, varieties and species in medicinal and aromatic crops;
3. Floral biology;
4. Selfing and crossing;
5. Evaluation of hybrid progenies;
6. Induction of economic mutants;

7. High alkaloid and high essential oil mutants;
8. Evolution of mutants through physical and chemical mutagens;
9. Introduction of polyploidy;
10. Screening of plants for biotic and abiotic stress;
11. *In-vitro* breeding in medicinal and aromatic crops.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

**SUGGESTED READINGS**


1. Chadha, K.L. and Gupta, R. 1995. *Advances in Horticulture*. Vol. XI. Malhotra Publ. House.
2. Farooqi, A.A., Khan, M.M. and Vasundhara, M. 2001. *Production Technology of Medicinal and Aromatic Crops*. Natural Remedies Pvt. Ltd.
3. Gupta, R.K. 2010. *Medicinal and Aromatic plants*. CBS publications
4. Jain, S.K. 2000. *Medicinal Plants*. National Book Trust.
5. Julia, F. and Charters, M.C. 1997. *Major Medicinal Plants– Botany, Cultures and Uses*. Thomas Publ.
6. Kurian, A and AshaSankar, M. 2007. *Medicinal Plants*. Horticulture Science Series, NIPA.
7. Ponnuswami *et al.* 2018. *Blossom biology of Horticultural crops*. Narendra Pub. H., New Delhi
8. Ponnuswami *et al.* 2018. *Botany of Horticultural crops*. Narendra Pub. H., New Delhi
9. Ponnuswami *et al.* 2018. *Medicinal Herbs and herbal cure*. Narendra Pub. H., New Delhi
   Waghulkar, V.M. 2012. *Quality assurance techniques in pharmaceuticals*. NIPA, New Delhi


## PSM 523 UNDEREXPLOITED PLANTATION, SPICE, MEDICINAL AND AROMATIC PLANTS 2(2+0)

**WHY THIS COURSE?**

There are many numbers of underexploited plantations, spice, medicinal and aromatic crops which are becoming important in line with the major ones. They could very well be the major crops of tomorrow. This course will impart comprehensive knowledge to the learner on the importance and scientific production technology of various underutilised plantation, spice, medicinal and aromatic plants in India.

**AIM OF THIS COURSE**

To facilitate understanding on the importance and cultivation of underutilized and lesser known plantation, spice, medicinal and aromatic plants.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Importance and status | 1. Importance and uses |
| | | 2. Status and future prospects |
| 2. | Production technology | 1. Propagation and varieties |
| | | 2. Agro techniques |
| 3. | Harvest and post-harvest management | 1. Harvest indices |
| | | 2. Post-harvest management |

**COURSE OUTCOME**

After successful completion of this course, the students are expected to:

1. Be thorough with the importance and commercial production technology of underutilized and lesser known plantation, spice, medicinal and aromatic plants.
2. be able to start underutilized and lesser known plantation, spice, medicinal and aromatic plants-based enterprises

**THEORY**

**Block 1: Importance and status**

**UNIT-I:** *Importance and Uses:* Introduction, importance, economic parts used, traditional uses

**UNIT-II:** *Status and future prospects:* Present status, origin, distribution and future prospects of under exploited PSMAs

**Block 2: Production technology**

**UNIT-I:** ***Propagation and varieties***: Propagation and nursery techniques, species varieties

**UNIT-II:** ***Agro techniques***: Climatic and soil requirements, planting and after care, weed and water management, manuring, plant protection

**Block 3: Harvest and post-harvest management**

**UNIT-I:** ***Harvest indices***: Maturity indices, harvesting time, techniques, crop duration

**UNIT-II:** ***Post harvest management***: Primary processing, extraction and value addition, storage, active ingredients

**CROPS:**

A. ***Plantation crops***: Wattle, minor species of Areca, Coffea, Hevea

B. ***Spice crops***: *Illicium verum, Myristica malabarica, M. beddomei, Cinnamomum tamala, C. malabatrum, Xanthoxylum sp., Curcuma caesia, C. aromatica, C. zedoaria, C. amada, Anethum graveolense, Hyssopus officinalis, Eringium foetidum, Pimpinella anisum, Artocarpus lacucha.*

C. ***Medicinal plants***: *Flacourtia montana, Plectranthus aromaticus, Adhatoda* sp., *Hemidesmus indicus, Tinospora cordifolia, Gymnema sylvestre, Psoralea corylifolia, Eclipta alba, Aristalochia indica, Morinda citrifolia, Caesalpinia sappan, Terminalia chebula, T. bellerica, Phyllanthus amarus, Strychnos nuxvomica,, S. indicum, S. xanthocarpum, Aegle marmelos, Alpinia* sp., *Hibiscus subdariffa, Anthocephalus kadamba, Costus* sp., *Kaempferia rotunda, K. parviflora, Picrorrhiza kurroa, Nardostachis jatamansi,Valeriana officinalis, Swertia chiraita, Aconitum sp., Salvia officinalis, Centella asiatica, Bixa orellana, Bacopa monnieri*

D. ***Aromatic plants***: *Bursera* sp., *Commiphora wightii, Ocimum kilimandjaricum,* Melaleuca, *Michaelia champaka, Rosa damascena, Cananga odorata*, marjoram, chamomile

**PRACTICAL**

1. Botanical characteristics of species and varieties of various underexploited plantation, spice, medicinal and aromatic plants;
2. Economic parts and their products;
3. Propagation and nursery techniques;
4. Harvesting and primary processing of underutilised PSMAs;
5. Exposure visits to institutes, botanical gardens, herbal gardens and distillation units.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

**SUGGESTED READINGS**


1. Atal, C.K. and Kapur, B.M. *Cultivation and Utilization of Aromatic plants*. R.R.L. Jammu
2. Barche, Swati. 2016. *Production technology of spices, aromatic, medicinal and plantation crops*. New India Publishing Agency, New Delhi
3. Chadha, K.L. and Gupta, R. 1995. *Advance in Horticulture*. Vol. XI. *Medicinal and Aromatic Plants.* Malhotra Publ. House. CSIR, The Wealth of India. Volume A-Z CSIR
4. Farooqui, A.A., Khan, M.M. and Sreeramu, B.S. 1997. *Cultivation of Medicinal and Aromatic Crops in India.* Naya Prokash.
5. Jain, S.K. 1979. *Medicinal Plants*. National Book Trust.
6. Kurian, A. and AshaSankar M. 2007. *Medicinal Plants*. Horticulture Science Series, NIPA.
7. Nybe, E.V., Mini Raj, N and Peter, K. V.2007. *Spices*. Horticulture Science Series, NIPA.
8. Peter, K.V. *Under exploited and underutilized Horticulture crops*. Volume I-IV. NIPA.
9. Ponnuswami *et al.* 2018. *Blossom biology of Horticultural cro*ps. Narendra Pub. H, New Delhi
10. Ponnuswami *et al.* 2018. *Botany of Horticultural crop*s. Narendra Pub. H, New Delhi
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14. Sivarajan, V.V. and Balachandran, I. 1994. *Ayurvedic Drugs and their Plant Sources*. Oxford and IBH.

## PSM 524 GROWTH AND DEVELOPMENT OF PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS 3(2+1)

**WHY THIS COURSE?**

Understanding on growth and development of plantation, spice, medicinal and aromatic crops is vital towards quality production as well as yield. Fundamental knowledge on developmental physiology, biology and biochemistry and the associated changes is most essential. This course will impart theoretical as well as hands-on experience to the learner on these aspects of PSMA crops for improving their productivity.

**AIM OF THIS COURSE**

To impart comprehensive knowledge on the growth, developmental stages and crop regulation to increase the productivity in PSMAs.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Growth and development | 1. Stages of growth |
| | | 2. Growth pattern |
| | | 3. Assimilate partitioning |
| 2. | Canopy management | 1. Canopy management |
| | | 2. Plant bio regulators |
| 3. | Developmental physiology and biochemistry | 1. Vegetative phase |
| | | 2. Flowering and fruit set |
| | | 3. Growth and development during stress |

**COURSE OUTCOME**

After successful completion of this course, the students are expected to
1. have thorough understanding on growth and development of PSMA crops
2. will enable them to formulate crop regulation strategies for productivity enhancement.

**THEORY**

**Block 1: Growth, development, assimilate partitioning and plant bio regulators**

**UNIT-I**: ***Stages of growth***: Growth and development, definitions, components, photosynthetic productivity, different stages of growth, growth curves, growth analysis, morphogenesis in PSMAs.

**UNIT-II: *Growth pattern***: in annual, semi-perennial and perennial crops, growth dimorphism, environmental impact on growth and development: effect of light, temperature, photoperiod.

**UNIT-III: *Assimilate partitioning***: Assimilate partitioning during growth and development, influence of water and mineral nutrition,

**Block 2: Canopy management**

**UNIT-I: *Canopy management***: Canopy management for conventional and high density planting pruning, training, chemicals, crop regulation for year round and off season production in PSMAs

**UNIT-II: *Plant bioregulators***: plant bio regulators- auxins, gibberellins, cytokinins, ethylene, inhibitors and retardants, basic functions, biosynthesis and role in crop growth and development

**Block 3: Developmental physiology and biochemistry**

**UNIT-I: *Vegetative phase***: Developmental physiology and biochemistry during dormancy, bud break, juvenility

**UNIT-II: *Flowering and fruit set***: Physiology of flowering, photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism, pollination, fertilisation, fruit set, fruit drop, fruit growth, ripening, seed development in PSMAs.

**UNIT-III: *Growth and development process during stress***: Growth and development process during stress, production of secondary metabolites, molecular and genetic approaches in growth and development.

**PRACTICAL:**

1. Dormancy mechanisms in seeds, seed rhizomes;
2. Techniques of growth analysis;
3. Evaluation of photosynthetic efficiency under different environments;
4. Technologies for crop regulation in cashew, coffee, cocoa *etc;*
5. Root shoot studies, flower thinning, fruit thinning;
6. Crop regulation for year round production;
7. Use of growth regulators in PSMA crops.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Demonstrations
- Exposure visits

**SUGGESTED READINGS**


1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology*. CRC Press
2. Buchanan, B.W. Gruiessam and Jones, R. 2002. *Biochemistry and Molecular Biology of Plant*s. John Wiley and Sons.
3. *e-manual on Advances in Cashew Production Technology*. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
4. Epstein, E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. Wiley.
5. Fosket, D.E. 1994. *Plant Growth and Development: A Molecular approach*. Academic Press.
6. Leoplod, A.C and Kriedermann, P.E. 1985. *Plant Growth and Development*. 3rdEd.McGraw-Hill
7. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
8. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
9. Pillay. P.N.R. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668
10. Ravindran, P.N. 2000. *Black pepper, Piper nigrum*. CRC press
11. Ravindran, P.N. 2002. *Cardamom, the genus Elettaria*. CRC press
12. Ravindran, P.N. 2003. *Cinnamon and cassia*. CRC press
13. Ravindran, P.N. 2004. *Ginger, the genus Zingiber*. CRC press
14. Ravindran, P.N. 2007. *Turmeric, the genus curcuma*. CRC press
15. Ravindran, P.N. 2017. *The Encyclopedia of Herbs and Spices*. CABI
16. Roberts, J.S. Downs and P. Parker. 2002. *Plant Growth Development. In: Plants* (L. Ridge, Ed.), pp. 221-274, Oxford University Pre
17. Salisbur, F.B. and Ross, C.W. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.
18. Sera, T., Soccol, C.R., Pandey, A., Roussos, S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.

    Sethuraj, M.R. and Mathew, N.T. 1992. *Natural Rubber: Biology, Cultivation and Technology* (Developments in Crop Science). Elsevier Science.


## PSM 525 SYSTEMATICS OF PLANTATION AND SPICE CROPS 2(1+1)

**WHY THIS COURSE?**

Plantation and spice crops play an important role in the national economy of India. For the crop improvement programme of these crops, fundamental knowledge on origin and development, evolutionary process, taxonomy and cytogenetics and is most essential. This course will impart theoretical knowledge to the learner on the origin and distribution, evolutionary process, taxonomy and cytogenetics of various plantation and spice crops.

**AIM OF THIS COURSE**

To impart basic knowledge on the origin and development, evolutionary process, taxonomy, chemotaxonomy, cytogenetics and genetic resources of plantation and spice crops.

**COURSE OUTCOME**

After successful completion of this course, the students are expected to have thorough understanding on the systematics of plantation and spice crops.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Origin and evolution | 1. Centre of origin |
| | | 2. Systematics |
| 2. | Genetic diversity | 1. Species and cultivar diversity |
| | | 2. Germplasm |
| 3. | Cataloguing | 1. Descriptors |
| | | 2. DUS guidelines |

**THEORY**

**Block 1: Origin and evolution**

**UNIT-I:** *Centre of origin:* Centre of origin, distribution, taxonomical status, phylogeny

**UNIT-II:** *Systematics:* Botany, cytology, ploidy status, sex forms, flowering and pollination biology, cytogenetics

**Block 2: Diversity**

**UNIT-I:** *Species and cultivar diversity:* Wild and related species, cultivars

**UNIT-II:** *Germplasm:* Indigenous and exotic germplasm

**Block 3: Cataloguing**

**UNIT-I:** *Descriptors:* Biovarsity/NBPGR descriptors and their salient features

**UNIT-II:** *DUS guidelines:* DUS guidelines, molecular aspects of systematics

**CROPS:**

A. *Plantation crops:* Coconut, Arecanut, Oil Palm, Tea, Coffee, Cocoa, Cashew, Rubber, Betel Vine

B. *Spice crops:* Black Pepper, Cardamom, Ginger, Turmeric, Nutmeg, Cinnamon, Clove, Vanilla, Coriander, Fennel, Cumin, Fenugreek, Garlic

**PRACTICAL**

1. Genus, species and cultivar features of various plantation and spice crops;
2. Characterization based on descriptors;
3. Characterization based on DUS guidelines;
4. Study of sex forms and floral biology;
5. Study of molecular markers;
6. Exposure visits to national institutes including NBPGR.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

**SUGGESTED READINGS**


1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology*. CRC Press.
2. Chadha, K.L. and Gupta, R. 1995. *Advances in Horticulture*. Vol. XI. Malhotra Publ. House.
3. Charles Burnham. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications,
4. Diwan, A.P and Dhakad, N.K. 1996. *Genetics and Development.* Anmol Pub. Pvt. Ltd
5. *e-manual on Advances in Cashew Production Technology*. ICAR –Directorate of Cashew Research, Puttur –574 202, DK, Karnataka.
6. Girish Sharma. 2009. *Systematics of fruit Crops*. New India Publishing House, India.
7. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
8. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
9. Pillay. P.N.R. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668.
10. Ponnuswami *et al.* 2018. *Blossom biology of Horticultural crops*. Narendra Publishing House, New Delhi.
11. Ponnuswami *et al.* 2018. *Botany of Horticultural crops*. Narendra Publishing House, New Delhi

12. Ravindran, P.N. 2000. *Black pepper, Piper nigrum*. CRC press.
13. Ravindran, P.N. 2002. *Cardamom, the genus Elettaria*. CRC press.
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15. Ravindran, P.N. 2004. *Ginger, the genus Zingiber*. CRC press.
16. Ravindran, P.N. 2007. *Turmeric, the genus curcuma*. CRC press.
17. Ravindran, P.N. 2017. *The Encyclopedia of Herbs and Spices*. CABI.
18. Sera, T., Soccol, C.R., Pandey, A. and Roussos S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
19. Sethuraj, M.R. and Mathew, N.T.1992. *Natural Rubber: Biology, Cultivation and Technology* (Developments in Crop Science). Elsevier Science.
20. Strickberger, M.W. 2005. *Genetics* (III Ed). Prentice Hall, New Delhi
21. Tamarin, R.H. 1999. *Principles of Genetics*. Wm. C. Brown Publishers.

## PSM 531 BIOCHEMISTRY OF PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS 3(2+1)

**WHY THIS COURSE?**

Postharvest physiology and biochemistry of plantation, spice, medicinal and aromatic crops contributes immensely towards quality improvement in crude as well as processed products. Fundamental knowledge on biochemistry of various crops is also essential for formulating their management practices in the field. This course will impart theoretical as well as hands-on experience to the learner on the biochemistry of PSMA crops.

**AIM OF THIS COURSE**

To impart comprehensive knowledge on the biochemistry, production of primary and secondary metabolites and the extraction of bioactive principles from PSMAs.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Post-harvest physiology | Physiological and biochemical changes |
| | | Contaminants |
| 2. | Value addition | Value added products |
| | | Quality standards |
| 3. | Extraction techniques | Extraction techniques |
| | | Plant tissue culture |

**COURSE OUTCOME**

After successful completion of this course, the students are expected to develop the technical know- how on postharvest biochemistry of plantation, spice, medicinal and aromatic crops.

**THEORY**

**Block 1: Post harvest physiology**

**UNIT-I:** *Physiological and biochemical changes:* Maturity indices, changes during ripening, processing, factors affecting quality. Secondary metabolites and their biosynthetic pathways, factors affecting production of secondary metabolites

**UNIT-II:** *Contaminants:* Adulterants, and substitutes, sources of contamination- microbial, heavy metal, pesticide residues in PSMAs

**Block 2: Value addition**

**UNIT-I:** *Value added products:* Fixed oils, essential oils, dyes, oleoresins, aroma chemicals and other value added products, their content, storage, medicinal and pharmacological properties, use in the food ,flavour perfumery and pharmaceutical industries

**UNIT-II:** *Quality standards:* Quality standards of raw materials and finished products.

**Block 3: Extraction techniques**

**UNIT-I:** *Extraction methods:* Basic and advanced extraction techniques in PSMAs-Soxhlet, SCFE, Membrane extraction. Chemical characterization-HPTLC, GCMS, LCMS, NMR

**UNIT-II:** *Plant tissue culture:* Plant tissue cultures in the industrial production of bioactive plant metabolites. Cell suspension culture systems for large scale culturing of plant cells and production of secondary metabolites. Advantages of cell culture over conventional extraction techniques.

**PRACTICAL**

1. Biochemical characterisation;
2. Detection of adulterants and substitutes;
3. Extraction and quantification of secondary metabolites;
4. Chromatographic separation of the products;
5. Quality assurance;
6. Testing the product;
7. Exposure visit to leading industries;
8. Assessment of antimicrobial properties;
9. In vitro production of secondary metabolites.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

**SUGGESTED READINGS**

1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology*. CRC Press
2. Daniel, M. and Mammen, D. 2016.*Analytical methods for medicinal plants and economic botany*. Scientific publishers
3. Das, K. 2013. *Essential oils and their applications*. New India Publishing Agency, New Delhi
4. *E-manual on Advances in Cashew Production Technology*. ICAR-Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
5. Hammon, J.M. and Yusibov, V. 2000. *Plant Biotechnology: New Products and application*. Springer-Verlag.
6. Orhan, I. 2012. *Biotechnological Production of Plant Secondary Metabolites*. Bentham Science Publishers
7. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
8. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
9. Parimelzhagan, T. 2013. *Turning plants into medicines: Novel approaches*. New India Publishing Agency, New Delhi
10. Pillay. P.N.R. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668
11. Ponnuswami *et al*. 2018 *Medicinal Herbs and herbal cure*. Narendra Pub. House, New Delhi
12. Raaman, N. 2006. *Phytochemical techniques*. New India Publishing Agency, New Delhi
13. Raju, R. Wadekar. 2015. *Pharmacognosy and phytochemistry*, Event publishing house
14. Ramawat, K.G. 2007. *Biotechnology: secondary metabolites: plants and microbes*. Science Pub.
15. Ranjal Kandall. *Bioactive compounds and genomic study of medicinal plants*. LAMBERT Academic Publishing
16. Sera, T., Soccol, C.R., Pandey, A., Roussos, S. Coffee Biotechnology and Quality. Springer, Dordrecht.
17. Sethuraj, M.R. and Mathew, N.T. 1992. *Natural Rubber: Biology, Cultivation and Technology* (Developments in Crop Science). Elsevier Science.
18. Shah, B and Seth, A.K. 2005. *Text book of Pharmacognosy and Phytochemistry*. CBS Publishers and distributors, New Delhi.
19. Shankar, S.J. 2018. *Comprehensive post-harvest technology of flowers, medicinal and aromatic plants*. Narendra Publishing House, New Delhi
20. Shukla, Y.M. 2009. *Plant secondary metabolites*. New India Publishing Agency, New Delhi
21. Syed Aftab Iqbal and Noor Ahmed Khan. 1993. *Text book of Phytochemistry*. Discovery Publishing house Pvt. Ltd
22. Tiwari/Chandra.2018. *Antimicrobial properties of Medicinal plants*. Narendra Pub.H. New Delhi
23. Trivedi, C. 2004. *Herbal drugs and biotechnology*. Pointer Publishers.
24. Waghulkar, V.M. 2012. *Quality assurance techniques in pharmaceuticals*. NIPA, New Delhi

## PSM 532 BIODIVERSITY AND CONSERVATION OF PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS 3(2+1)

**WHY THIS COURSE?**

India is the homeland of several plantation, spice, medicinal and aromatic crops. Biodiversity conservation is considered as the primary step in protecting the gene pool available in these crops. Fundamental knowledge on centres of diversity, germplasm evaluation, documentation, data base management and cataloguing is most essential. This course will impart theoretical as well as hands-on experience to the learner on these areas.

**AIM OF THIS COURSE**

To impart basic knowledge on natural as well as agro bio diversity, its value and conservation strategies with respect to PSMAs.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Plantation and spice crops | 1. Biodiversity |
| | | 2. Germplasm collection and quarantine |
| | | 3. Documentation and cataloguing |
| | | 4. National and international issues |
| 2. | Medicinal and aromatic crops | 1. Biodiversity |
| | | 2. Germplasm collection and quarantine |
| | | 3. Documentation and cataloguing |
| | | 4. National and international issues |

**COURSE OUTCOME**

1. After successful completion of this course, the students are expected to develop thorough understanding on biodiversity conservation of plantation, spice, medicinal and aromatic plants.

**THEORY**

**Block 1: Plantation and Spice crops**

**UNIT-I: *Biodiversity*:** Biodiversity, issues and goals, centres of origin of Plantation and spice crops, primary and secondary centres of genetic diversity

**UNIT-II: *Germplasm collection and quarantine*:** Exploration and germplasm collection, planning and logistics, exchange of germplasm, plant quarantine principles, regulations plant quarantine systems in India. Components of germplasm evaluation, descriptor lists. Conservation of genetics resources, Concept of base and active collections, long and short term storage of Plantation and spice crops, gene bank management

**UNIT-III: *Documentation and cataloguing*:** Recent approaches and role of biotechnology in PGR conservation documentation and data base management, cataloguing gene bank information. Molecular markers in characterisation of plant genetic resources. GIS in biodiversity mapping

**UNIT-IV: *National and international issues*:** Genetic resources management of Plantation and Spice crops in India and in International perspective. Utilization and achievements in major crops. Concepts of rarity, threat, endangerment and extinction in major plantation and spice crops. Bio diversity concerns, national and international regulations, conservation networks. Good collection practices, domestication, PPV and FRA and DUS testing. Geographical indication, Biodiversity act and biodiversity legislations.

**Block II: Medicinal and aromatic crops**

**UNIT-I: *Biodiversity*:** Biodiversity, issues and goals, centres of origin of medicinal and aromatic crops, primary and secondary centres of genetic diversity

**UNIT-II: *Germplasm collection and quarantine*:** Exploration and germplasm collection, planning and logistics, exchange of germplasm, plant quarantine principles, regulations plant quarantine systems in India. Components of germplasm evaluation, descriptor lists. Conservation of genetics resources, Concept of base and active collections, long and short term storage of Plantation and spice crops, gene bank management

**UNIT-III: *Documentation and cataloguing*:** Recent approaches and role of biotechnology in PGR conservation documentation and data base management, cataloguing gene bank information. Molecular markers in characterisation of plant genetic resources. GIS in biodiversity mapping

**UNIT-IV: *National and international issues***: Genetic resources management of Plantation and Spice crops in India and in International perspective. Utilization and achievements in major crops. Concepts of rarity, threat, endangerment and extinction in major plantation and spice crops. Bio diversity concerns, national and international regulations, conservation networks. Good collection practices, domestication, PPV and FRA and DUS testing. Geographical indication, Biodiversity act and biodiversity legislations

**PRACTICAL**

1. Collection and identification of different plantation, spice, medicinal and aromatic plants from natural sources;
2. Preparation of herbarium;
3. Botanical and phyto-chemical grouping of PSMAs;
4. Classification of PSMAs based on plant parts used;
5. Documentation of germplasm;
6. Maintenance of passport data and other records;
7. Field explorations;
8. Detection of adulterants and substitutes in PSMAs;
9. Ethno botanical studies in tribal areas;
10. Planning and layout of herbal gardens;
11. Exposure visits to herbaria, herbal gardens and important organisations engaged in collection and utilization of PSMAs.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Demonstrations
- Exposure visits

**SUGGESTED READINGS**


1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology*. CRC Press
2. Choudhari, A.B. *Mega diversity Conservation: Flora, Fauna and Medicinal Plants of India's hot spots.*
3. Devi, A.R; Sharangi, AB; Acharya, SK and Mishra GC. 2017. *Coriander in Eastern India: The landraces and genetic diversity*. Krishi Sanskriti Publications. New Delhi.
4. *E-manual on Advances in Cashew Production Technology.* ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
5. Kassahun Beemnet, Jemal Omar Sherif, TessemaTsion, Abate Solomon 2009. *Production, Processing and utilization of Aromatic Plants*. EIAR
6. Khan, J.B. and Singh, G.P. 2012. *Biodiversity Management and Conservation* LAMBERT
7. Negi, S.S. *Biodiversity of India and its Conservation.*
8. Panda, H. 2002. *Medicinal Plants Cultivation and their Uses*. Asia Pacific Business Press.
9. Panda, H. 2005. *Aromatic Plants Cultivation, Processing and Uses*. Asia Pacific Business Press
10. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
11. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
12. Panda, H. 2017. *Herbal and Aromatic Plants Cultivation, Processing, Utilization and Applications*. Discovery publishing house, New Delhi
13. Pillay. P. N. R. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668
14. Ponnuswami *et al.* 2018. *Medicinal Herbs and herbal cure*. Narendra Pub. House, New Delhi
15. Ponnuswami *et al.* 2018. *Spices*. Narendra Publishing House, New Delhi
16. Pullaiah, T. 2011. *Biodiversity in India* Vol. 5. Daya Publishing house
17. Rajak, R.C. and Rai, M.K. *Herbal Medicines, Biodiversity and Conservation strategies*. IBH.
18. Ramakrishnan, N.2018. *Biodiversity in Indian Scenario*. Daya publishing house.
19. Sera, T., Soccol, C.R., Pandey, A., Roussos, S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
20. Sethuraj, M.R. and Mathew, N.T. 1992. *Natural Rubber: Biology, Cultivation and Technology* (Developments in Crop Science). Elsevier Science.

21. Thirugnanakumar 2018. *Genetic diversity and phenotypic stability in crop plants*. New India Publishing Agency, New Delhi
22. Trivedi, P.C. *Medicinal Plants: Utilization and Conservation.*

## PSM 533 SYSTEMATICS OF MEDICINAL AND AROMATIC CROPS 2(1+1)

**WHY THIS COURSE?**

Medicinal and aromatic crops play an important role in the national economy of India. For the crop improvement programme of these crops, fundamental knowledge on origin and development, evolutionary process, taxonomy and cytogenetics is most essential. This course will impart theoretical knowledge to the learner on the origin and distribution, evolutionary process, taxonomy and cytogenetics of various medicinal and aromatic crops.

**AIM OF THIS COURSE**

To impart basic knowledge on the origin and development, evolutionary process, taxonomy, cytogenetics and genetic resources of medicinal and aromatic crops.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Origin and evolution | 1. Centre of origin |
| | | 2. Systematics |
| 2. | Genetic diversity | 1. Species and cultivar diversity |
| | | 2. Germplasm |
| 3. | Cataloguing | 1. Descriptors |
| | | 2. DUS guidelines |

**COURSE OUTCOME**

1. After successful completion of this course, the students are expected to have thorough understanding on the systematics of medicinal and aromatic crops.

**THEORY**

**Block 1: Origin and evolution**

**UNIT-I:** *Centre of origin:* Centre of origin, distribution, taxonomical status, phylogeny, chemotaxonomy

**UNIT-II:** *Systematics:* Botany, cytology, ploidy status, sex forms, flowering and pollination biology, cytogenetics

**Block 2: Genetic Diversity**

**UNIT-I:** *Species and cultivar diversity*: Wild and related species, cultivars

**UNIT-II:** *Germplasm:* Indigenous and exotic germplasm

**Block 3: Cataloguing**

**UNIT-I:** *Descriptors:* Biovarsity /NBPGR descriptors and their salient features

**UNIT-II:** *DUS guidelines:* DUS guidelines, molecular aspects of systematics

**CROPS:**

1. *Medicinal crops:* Opium poppy, Isabgol, Aswagandha, Senna, Medicinal coleus, Glory Lily, Periwinkle, Sarpagandha, Long Pepper, Stevia, Safed musli, *Plumbago zeylanica*

2. *Aromatic crops:* Lemongrass, Citronella, Palmarosa, Vetiver, Mint, Patcholi, Geranium, Ocimum, Rosemary, Lavender, *Kaempferia galanga*, Eucalyptus

**PRACTICAL**

1. Genus, species and cultivar features of various medicinal and aromatic crops;
2. Characterization based on descriptors;
3. Characterization based on DUS guidelines;
4. Study of sex forms and floral biology;
5. Study of molecular markers;
6. Exposure visits to national institutes including NBPGR.

**TEACHING METHODS/ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

**SUGGESTED READINGS**

1. Birel Shah and Seth, A.K. 2005. *Text book of Pharmacognosy and Phytochemistry*. Cbs Publishers and distributors, New Delhi.
2. Charles Burnham. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications
3. Diwan, A.P and Dhakad, N.K. 1996. *Genetics and Development*. Anmol Pub Pvt. Ltd.
4. Farooqi, A.A., Khan, M.M. and Vasundhara, M. 2001. *Production Technology of Medicinal and Aromatic Crops*. Natural Remedies Pvt. Ltd.
5. Gupta, R.K. 2010. *Medicinal and Aromatic plants*. CBS publications
6. Prajapati, N.D., Purohit, S.S., Sharma, A.K, Kumar, T. 2006. *A Handbook of Medicinal Plants*. Agro Bios (India).
7. Ponnuswami *et al.* 2018. *Blossom biology of Horticultural crops*. Narendra Publishing House, New Delhi.
8. Ponnuswami *et al.* 2018. *Botany of Horticultural crops*. Narendra Publishing House, New Delhi
9. Raju, R. Wadekar. 2015. *Pharmacognosy and phytochemistry*, Event publishing house
10. Ranjal Kandall. *Bioactive compounds and genomic study of medicinal plants*. LAMBERT.
11. Sharma, G. 2009. *Systematics of fruit Crops*. New India Publishing House, India.
12. Skaria P Baby et al. 2007. *Aromatic Plants*. New India Publ. Agency.
13. Strickberger, M.W. 2005. *Genetics* (III Ed). Prentice Hall, New Delhi, India
14. Tamarin, R.H. 1999. *Principles of Genetics*. Wm. C. Brown Publishers
15. Thakur, R.S., Pauri, H.S. and Hussain, A. 1989. *Major Medicinal Plants of India*. CSIR.

# COURSE CONTENTS: Ph.D. PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS

## PSM 611 ADVANCES IN PRODUCTION OF PLANTATION AND SPICE CROPS 3(3+0)

**WHY THIS COURSE?**

Plantation and spice crops play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers. This course will impart knowledge to the learner on advanced scientific production technology of various plantation and spice crops in Indian perspectives. Hi-tech production technologies will be discussed in this course.

**AIM OF THIS COURSE**

The course is designed to provide advanced crop production techniques of various plantation and spice crops grown in India.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Importance of Plantation and spice Crops | 1. Area, production, productivity: Indian and world scenario |
| | | 2. Export potential |
| | | 3. Promotional programmes |
| 2. | Advanced agro techniques | 1. Varietal wealth and planting material production |
| | | 2. Agro techniques |
| | | 3. Impact of climate change |
| 3. | Harvest and post-harvest management | 1. Maturity indices and harvest |
| | | 2. Quality standards |

**COURSE OUTCOME**

After successful completion of this course, the students are expected to:

1. be equipped with the latest research outcome in commercial cultivation of plantation and spice crops and
2. be able to start hi-tech plantation and spice crop based enterprises.

**THEORY**

**Block 1. Importance of Plantation and Spice Crops**

**UNIT-I:** *Area, production, productivity: Indian and world scenario*: Role of plantation and spice crops in national economy, area-production statistics at national and international level, productivity challenges, industrial requirement of plantation and spice crops, demand-supply scenario of plantation and spice crop.

**UNIT-II:** *Export potential:* Export scenario, market opportunities and challenges in plantation and spice crops, global imports and exports, export of organic produce and products

**UNIT-III:** *Promotional programmes:* Role of commodity boards and directorates in the development programmes of plantation and spice crops, contract farming, Farmer Producer Organizations (FPO) and Farmer Producer Companies (FPC)

**Block 2. Advanced Agro techniques**

**UNIT-I:** *Varietal wealth and planting material production*: Cultivars and improved varieties in plantation and spice crops, mass multiplication techniques, hi-tech nursery techniques.

**UNIT-II:** *Agro techniques:* Precision farming techniques, HDP systems, fertigation, chemical regulation of crop productivity, protected cultivation of high value crops ,mechanization in plantation and spice crops, hydroponics, aeroponics, application of nanotechnology, robotics

**UNIT-III:** *Impact of climate change*: Impact of biotic and abiotic factors on growth and productivity, climate resilient technologies in plantation and spice crops, soil health management, organic production systems

**Block 3. Harvest and postharvest management**

**UNIT-I:** *Maturity indices and harvest:* Influence of pre and post-harvest factors on quality of plantation and spice crops, pre and post-harvest management techniques for improving quality, good manufacturing practices in plantation and spice sector

**UNIT-II:** *Quality standards:* Domestic and international standards, HACCP, BIS standards, domestic and export grades, modern packaging techniques, export protocols.

Crops: Coconut, Arecanut, Oil palm, Cashew ,Coffee, Tea, Cocoa, Rubber, Palmyrah, Black pepper, Cardamom, Ginger, Turmeric, Nutmeg, Cinnamon, Clove, Vanilla, Garcinia, Coriander, Cumin, Fennel, Fenugreek, Ajowain, Dill, Saffron.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Presentation of review papers and research articles
- Exposure visits to research centres, industries

**SUGGESTED READINGS**


1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology*. CRC Press
2. Agarwal, S., Divkara Sastry, E.V. and Sharma, R.K. 2001. *Seed Spices, Production, Quality and Export.* Pointer Publ.
3. Anonymous, 1985. *Rubber and its Cultivation*. The Rubber Board of India.
4. Barche, S. 2016. *Production Technology of Spices, Aromatic, Medicinal and Plantation Crops*. New India Publishing Agency, New Delhi.
5. Chadha, K.L. 2001. *Hand Book of Horticulture*. ICAR.
6. Chopra, V.L. and Peter, K.V. 2005. *Handbook of Industrial Crops*. Panima.
7. Choudappa, P., Anitha, K., Rajesh, M.K., and Ramesh, S.V. 2017. *Biotechnology of Plantation Crops.* Daya Publishing House, New Delhi
8. Choudappa, P., Niral, V., Jerard, B.A. and Samsudeen, K. 2017. *Coconut.* Daya Publishing House, New Delhi.
9. *E-manual on Advances in Cashew Production Techn*ology. ICAR-Directorate of Cashew Research, Puttur –574 202, D.K., Karnataka.
10. Harler, C.R. 1963. *The Culture and Marketing of Tea*. Oxford Univ. Press.
11. Joshi, P. 2018. *Text Book on Fruit and Plantation Crops*. Narendra Publishing House, New Delhi.
12. Kurian, A. and Peter, K.V. 2007. *Commercial Crops Technology*. New India Publ. Agency.
13. Marsh, A.C., Moss, M.K., and Murphy, E.W. 1977. *Composition of Food Spices and Herbs, Raw, Processed and Prepared.* Agric. Res. Serv. Hand Book 8-2. Washington DC.
14. Nair, M.K, Bhaskararao, E.V.V., Nambiar, K.K.N., and Nambiar, M.C. 1979. *Cashew*. CPCRI, Kasaragod.
15. Nybe, E.V, Mini Raj, N., and Peter, K.V. 2007. *Spices*. New India Publ. Agency.
16. Panda, H. 2013. *The Complete Book on Cas*hew. Asia Pacific Business Press Inc.
17. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Te*a (2nd Revised Edition). Asia Pacific Business Press Inc.
18. Peter, K.V. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ. Co., UK and CRC, USA.
19. Peter, K.V. 2002. *Plantation Crops*. National Book Trust.
20. Pillay, P.N.R. 1980. *Handbook of Natural Rubber Production in India.* Rubber Research Institute, Kottayam. pp.668
21. Ponnuswami *et al.* 2018. *Spices*. Narendra Publishing House, New Delhi
22. Pradeepkumar, T., Suma, B., Jyothibhaskar and Satheesan, K.N. 2007. *Management of Horticultural Crops*. Parts I, II. New India Publ. Agency.
23. Purseglove, J.W, Brown, E.G., Green, C.L., and Robbins, S.R.J. 1984. *Spices*. Vols. I, II. Longman.
24. Purseglove, J.W. 1968. *Tropical Crops–Dicotyledons*. Longman.
25. Ramachandra et al. 2018. *Breeding of Spices and Plantation crops*. Narendra Publishing House, New Delhi
26. Ranganathan, V. 1979. *Hand Book of Tea Cultivation*. UPASI, Tea Res. Stn. Cinchona.
27. Ravindran, P.N. 2003. *Cinnamon and cassia*. CRC press
28. Ravindran, P.N. 2004. *Ginger, the genus Zingiber*. CRC press
29. Ravindran, P.N. 2007. *Turmeric, the genus curcuma*. CRC press, *Medicinal and Aromatic Plants - Industrial Profiles*. Routledge, UK.

30. Ravindran, P.N. 2001. *Monograph on Black Pepper*. CRC Press.
31. Ravindran, P.N. 2017. *The Encyclopedia of Herbs and Spices*. CABI
32. Ravindran, P.N. and Madhusoodanan, K.J. 2002. *Cardamom, the Genus Elettaria*. CRC press.
33. Sera, T., Soccol, C.R., Pandey, A., and Roussos, S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
34. Sethuraj, M.R. and Mathew, N.T. 1992. *Natural Rubber: Biology, Cultivation and Technology* (Developments in Crop Science). Elsevier Science.
35. Shanmugavelu, K.G., Kumar, N., and Peter, K.V. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.
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37. Sharangi, A.B. and Datta, S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.
38. Sharangi, A.B, Datta, S., and Deb, P. 2018. *Spices: Agrotechniques for quality produce*, April, Academic Press (Tylor and Francis Groups), New Jersey, USA.
39. Sharangi, A.B. 2018. *Indian Spices: The legacy, production and processing of India's treasured export*. Springer International publishing. AG, Part of Springer Nature, 2018, Cham, Switzerland.
40. Srivastava, H.C, Vatsaya., and Menon, K.K.G. 1986. *Plantation Crops–Opportunities and Constraints.* Oxford and IBH.
41. Swain, S.C. 2018. *Precision Farming in Horticulture: Approaches and strategies*. Narendra Publishing House, New Delhi.
42. Thampan, P.K. 1981. *Hand Book of Coconut Palm.* Oxford and IBH.
43. Varmudy, V. 2001. *Marketing of Spices*. Daya Publ. House.
44. Winton, A.L. and Winton, K.B. 1931. *The Structure and Composition of Food*. John Wiley and Sons.
45. Yagna Narayan Ayer, A.K. 1960. *Cultivation of Cloves in India.* ICAR.


## PSM 612 ADVANCES IN PRODUCTION OF MEDICINAL AND AROMATIC CROPS 3(3+0)

**WHY THIS COURSE?**

Medicinal and aromatic crops play an important role in the national economy of India. They also cater to the primary health care needs of a large section of people. This course will impart knowledge to the learner on advanced scientific production technology of various medicinal and aromatic crops in Indian perspectives.

**AIM OF THIS COURSE**

The course is designed to provide latest developments and trends in the production technology of various medicinal and aromatic crops grown in India.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Importance of Medicinal and Aromatic Crops | 1. Biodiversity of medicinal and aromatic crops |
| | | 2. Area, production, productivity statistics |
| | | 3. Export potential |
| 2. | Advanced Agro techniques | 1. Domestication studies |
| | | 2. Varietal wealth and planting material production |
| | | 3. Agro techniques |
| | | 4. Impact of climate change |
| 3. | Harvest and post-Harvest Management | 1. Maturity indices and harvest |
| | | 2. Modern methods of extraction of MAPs |
| | | 3. Quality standards |

**COURSE OUTCOME**

After successful completion of this course, the students are expected to:

1. be equipped with the latest research out come in commercial cultivation of medicinal and aromatic crops

2. be able to start hi-tech medicinal and aromatic crop based enterprises

**THEORY**

**Block 1. Importance of Medicinal and Aromatic Crops**

**UNIT-I:** *Biodiversity of medicinal and aromatic crops (MAPs*): Biodiversity of MAPs, conservation networks, global initiatives on medicinal plants conservation and development, World history on usage of MAPs, preference to natural products .Indian traditional wisdom and heritage, Indian herbal wealth, documentations, databases, scientific validation.

**UNIT-II:** *Area, production and productivity statistics:* Role of medicinal and aromatic crops in national economy, area-production statistics at national and international level, productivity challenges, Trends in food, flavouring, perfumery and cosmetic industries, requirement in the ayurvedic, pharmaceutical, perfume and cosmetic industries, demand supply scenario of MAPs.

**UNIT-III:** *Export potential:* Export and import of crude drugs, standardized extracts, aromatic plants, essential oils. Intellectual Property Rights, patents. Contract farming. Role of Medicinal Plant Board in promotional programmes of MAPs

**Block 2. Advanced agro-techniques**

**UNIT-I:** *Domestication studies:* Need for domestication, changes on domestication, influence of environment on secondary metabolite production, developing cultivation packages for emerging crops

**UNIT-II:** *Varietal wealth and planting material production:* Cultivars and improved varieties in medicinal and aromatic crops, mass multiplication techniques, micropropagation, hi-tech nursery techniques,

**UNIT-III:** *Agro techniques:* Advanced research in the field of growth and development, nutrition and irrigation requirements, inter culture, mulching, weed control. Precision farming techniques, HDP systems, fertigation, chemical regulation of crop productivity, protected cultivation of high value crops, hydroponics, aeroponics, application of nanotechnology, nano-fertilizers, nano-pesticides, robotics.

**UNIT-IV:** *Impact of climate change:* Impact of biotic and abiotic factors on growth, productivity and quality, climate resilient technologies in medicinal and aromatic crops, soil health management, and organic production systems.

**Block 3. Harvest and post-harvest management**

**UNIT-I:** *Maturity indices and harvest:* Influence of pre and post-harvest factors on quality of medicinal and aromatic crops, pre and post-harvest management techniques for improving quality, good manufacturing practices in herbal sector

**UNIT-II:** *Modern methods of extraction of MAPs:* Advanced essential oil extraction and value addition methods in aromatic plants, advances in phytochemical extraction technologies, separation of bio-molecules, phytochemicals and drug development. Pharmacology and pharmacognosy, in vivo and in vitro extraction of secondary metabolites, bioreactors.

**UNIT-III:** *Quality standards:* Quality standards in medicinal and aromatic plants, quality standards in crude drugs and finished products, use of aroma chemicals, aroma therapy, advanced research in biomedicines, nutraceuticals and natural drugs, American, European and Asian legislations on plant drugs, domestic and international standards, modern packaging techniques.

**CROPS:**

A. *Medicinal crops:* Coleus, Glory lily, Senna, Periwinkle, Stevia, Aswagandha, Sarpagandha, Aloe, *Phyllanthus amarus*, *Andrographis paniculata*, Isabgol, Poppy, *Digitalis* sp., *Commiphora* sp., Ipecac, Henbane, *Ocimum* sp., Centella, Bacopa, Saraca, Valerian, Jatamansi, Aconits, Ephedra and Bael.

B. *Aromatic crops*: Palmarosa, Lemongrass, Citronella, Vetiver, Geranium, Artemisia, Mint, Eucalyptus, Rosemary, Thyme, Patchouli, Rose, Jasmine, Lavender.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Presentation of review papers and research articles

- Exposure visits to research centres, industries

**SUGGESTED READINGS**


1. Dharamvir, H. 2007. *Bioactive Medicinal Plants*. Gene Tech Books.
2. Farooqi, A.A. and Sriramu, A.H. 2000. *Cultivation Practices for Medicinal and Aromatic Crops*. Orient Longman Publ.
3. Farooqi, A.A., Khan, M.M., and Vasundhara, M. 2001. *Production Technology of Medicinal and Aromatic Crops.* Natural Remedies Pvt. Ltd.
4. Jain, S.K. 2000. *Medicinal Plants*. National Book Trust.
5. Khan, I.A. and Khanum, A. 2001. *Role of Biotechnology in Medicinal and Aromatic Plants*. Vol. IX. Vikaaz Publ.
6. Panda, H. 2002. *Medicinal Plants Cultivation and their Uses*. Asia Pacific Business Press.
7. Ponnuswami *et al.* 2018. *Medicinal Herbs and herbal cure*. Narendra Pub. House, New Delhi.
8. Prajapati, N.D., PaeroHit, S.S., Sharma, A.K., and Kumar, T. 2006. *A Hand Book of Medicinal Plants*. Agro Bios.
9. Ramawat, K.G., and Merillon, J.M. 2003. *Biotechnology–Secondary Metabolites*. Oxford and IBH.
10. Shankar, S.J. 2018. *Comprehensive post-harvest technology of flowers, medicinal and aromatic plants*. Narendra Publishing House, New Delhi.
11. Sharangi, A.B. and Acharya, S.K.2008. *Quality management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2
12. Sharangi, A.B. and Datta, S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.
13. Swain, S.C. 2018. *Precision farming in Horticulture: Approaches and strategies*. Narendra Publishing House, New Delhi.
14. Tiwari Chandra, 2018. *Antimicrobial properties of Medicinal plants*. Narendra Pub. H, New Delhi.


## PSM 621 RECENT BREEDING APPROACHES IN PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS 3(3+0)

**WHY THIS COURSE?**

Plantation, spice medicinal and aromatic crops (PSMA) play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers and cater to the primary health care needs of a large section of people. This course will impart knowledge to the learner on the advanced breeding approaches followed in important PSMA crops in Indian perspectives.

**AIM OF THIS COURSE**

The course is designed to provide knowledge on modern approaches in the breeding of various PSMA crops grown in India.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Plantation crops | 1. Genetic resources |
| | | 2. Breeding methods |
| | | 3. Breeding achievements |
| 2. | Spice crops | 1. Genetic resources |
| | | 2. Breeding methods |
| | | 3. Breeding achievements |
| 3. | Medicinal and Aromatic crops | 1. Genetic resources |
| | | 2. Breeding methods |
| | | 3. Breeding achievements |

**COURSE OUTCOME**

After successful completion of this course, the students are expected to:

1. be equipped with the latest research outcome in crop improvement of PSMA crops
2. be able to start hi-tech PSMA crop based seed/planting material production programmes.

**THEORY**

**Block 1. Plantation Crops**

**UNIT-I:** *Genetic resources:* Evolutionary mechanisms, adaptation and domestication, genetic resources, genetic divergence, cytogenetics, variations and natural selection, types of pollination and fertilization mechanisms, sterility and incompatibility systems in Plantation crops

**UNIT-II:** *Breeding methods:* Introduction and selection, chimeras, clonal selections, intergeneric, interspecific and inter-varietal hybridization, heterosis breeding, mutation and polyploidy breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, genetics of important traits and their inheritance pattern, molecular and transgenic approaches and other biotechnological tools in crop improvement.

**UNIT-III:** *Breeding achievements:* Breeding objectives, ideotype breeding, breeding problems and achievements in Plantation crops.

**Block 2. Spice crops**

**UNIT-I:** *Genetic resources:* Evolutionary mechanisms, adaptation and domestication, genetic resources, genetic divergence, cytogenetics, variations and natural selection, types of pollination and fertilization mechanisms, sterility and incompatibility systems in Spice crops

**UNIT-II:** *Breeding methods:* Introduction and selection, chimeras, clonal selections, intergeneric, interspecific and intervarietal hybridization, heterosis breeding, mutation and polyploidy breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, genetics of important traits and their inheritance pattern, molecular and transgenic approaches and other biotechnological tools in crop improvement.

**UNIT-III:** *Breeding achievements:* Breeding objectives, ideotype breeding, breeding problems and achievements in Spice crops.

**Block 3. Medicinal and aromatic crops**

**UNIT-I:** *Genetic resources:* Evolutionary mechanisms, adaptation and domestication, genetic resources, genetic divergence, cytogenetics, variations and natural selection, chemotaxonomy, pollination and fertilization mechanisms, sterility and incompatibility systems in Medicinal and Aromatic crops.

**UNIT-II:** *Breeding methods:* Introduction and selection, , clonal selections, intergeneric, interspecific and intervarietal hybridization, heterosis breeding, mutation and polyploidy breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, genetics of important traits and their inheritance pattern, genetic mechanisms associated with secondary metabolites, molecular and transgenic approaches and other biotechnological tools in crop improvement

**UNIT-III:** *Breeding achievements:* Specific breeding objectives in medicinal and aromatic crops, ideotype breeding, breeding problems and achievements in medicinal and aromatic crops.

**CROPS:**

A. *Plantation crops:* Coconut, Arecanut, Oil palm, Cashew, Coffee, Tea, Cocoa, Rubber

B. *Spice crops:* Black pepper, Cardamom, Ginger, Turmeric, Nutmeg, Cinnamon, Clove, Garcinia, Coriander, Cumin, Fennel, Fenugreek, Ajowain, Dill.

C. *Medicinal crops:* Senna, Periwinkle, Aswagandha, Isabgol, Sarpagandha, Poppy, Glory lily, Medicinal coleus, *Mucuna pruriens*, Ocimum, *Centella asiatica*, *Bacopa monnieri*, *Andrographis paniculata, Aloe vera, Phyllanthus amarus*, Eucalyptus, Bael, Henbane.

D. *Aromatic crops:* Lemongrass, Palmarosa, Citronella, Vetiver, Mint, Sweet basil, Lavender, Geranium, Patchouli, Artemisia, Rosemary, Thyme, Sage, Marjoram, Fever few.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Presentation of review papers and research articles
- Exposure visits to research centres, PSMA crop based industries.

**SUGGESTED READINGS**

1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology*. CRC Press.
2. Agarwal, S., Divkara Sastry, E.V. and Sharma, R.K. 2001. *Seed Spices, Production, Quality and Export*. Pointer Publ.
3. Anonymous, 1985. *Rubber and its Cultivation*. The Rubber Board of India.
4. Atal, C. and Kapoor, V. 1992. *Cultivation and Utilization of Medicinal and Aromatic Crops*. CSIR.
5. Barche, S. 2016. *Production technology of spices, aromatic, medicinal and plantation crops*. New India Publishing Agency, New Delhi.
6. Chadha, K.L. 2001. *Hand Book of Horticulture*. ICAR.
7. Chadha, K.L. and Gupta, R. 1995. *Advances in Horticulture*. Vol. XI. Malhotra Publ. House.
8. Chopra, V.L. and Peter, K.V. 2005. *Handbook of Industrial Crops*. Panima.
9. Choudappa, P., Anitha, K., Rajesh, M.K. and Ramesh, S.V. 2017. *Biotechnology of Plantation Crops*. Daya Publishing House, New Delhi.
10. Choudappa, P., Niral, V., Jerard, B.A. and Samsudeen, K. 2017. *Coconut*. Daya Publishing House, New Delhi.
11. *E-manual on Advances in Cashew Production Technology*. ICAR -Directorate of Cashew Research, Puttur –574 202, D.K., Karnataka.
12. Farooqi, A.A., Khan, M.M. and Vasundhara, M. 2001. *Production Technology of Medicinal and Aromatic Crops*. Natural Remedies Pvt. Ltd.
13. Handa, S.S. and Kaul, M.K. 1982. *Cultivation and Utilization of Medicinal Plants*. NISC, CSIR.
14. Harler, C.R. 1963. *The Culture and Marketing of Tea*. Oxford Univ. Press.
15. Jain, S.K. 2000. *Medicinal Plants*. National Book Trust.
16. Joshi, P. 2018. *Text Book on Fruit and Plantation Crops*. Narendra Publishing House, New Delhi.
17. Julia, F. and Charters, M.C. 1997. *Major Medicinal Plants–Botany, Cultures and Uses*. Thomas Publ.
18. Kurian, A. and Peter, K.V. 2007. *Commercial Crops Technology*. New India Publ. Agency.
19. Marsh, A.C., Moss, M.K. and Murphy, E.W. 1977. *Composition of Food Spices and Herbs, Raw, Processed and Prepared*. Agric. Res. Serv. Hand Book 8-2. Washington DC.
20. Nair, M.K., Bhaskararao, E.V.V., Nambiar, K.K.N. and Nambiar, M.C. 1979. *Cashew*. CPCRI, Kasaragod.
21. Nybe, E.V., Mini Raj, N. and Peter, K.V. 2007. *Spices*. New India Publ. Agency.
22. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
23. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Te*a (2nd Revised Edition). Asia Pacific Business Press Inc.
24. Peter, K.V. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ. Co., UK and CRC, USA.
25. Peter, K.V. 2002. *Plantation Crops*. National Book Trust.
26. Pillay, P.N.R. 1980. *Handbook of natural rubber production in India*. Rubber Research Institute, Kottayam, 668pp.
27. Ponnuswami *et al*. 2018. *Botany of Horticultural crops*. Narendra Publishing House, New Delhi.
28. Ponnuswami *et al*. 2018. *Medicinal Herbs and Herbal Cure*. Narendra Pub. House, New Delhi.
29. Ponnuswami *et al*. 2018. *Blossom biology of Horticultural crops*. Narendra Pub. H New Delhi.
30. Ponnuswami *et al*. 2018. *Spices*. Narendra Publishing House, New Delhi
31. Pradeepkumar, T., Suma, B., Jyothibhaskar and Satheesan, K.N. 2007. *Management of Horticultural Crops*. Parts I, II. New India Publ. Agency.
32. Prajapati, N.D., Purohit, S.S, Sharma, A.K. and Kumar, T. 2006. *A Handbook of Medicinal Plants*. Agro Bios.
33. Purseglove, J.W. 1968. *Tropical Crops–Dicotyledons*. Longman.
34. Purseglove, J.W., Brown, E.G., Green, C.L. and Robbins, S.R.J. 1984. *Spice*s. Vols. I, II. Longman.
35. Ramachandra *et al.* 2018. *Breeding of Spices and Plantation crops*. Narendra Pub. House, New Delhi.
36. Ranganathan, V. 1979. *Hand Book of Tea Cultivation*. UPASI, Tea Res. Stn. Cinchona.
37. Ravindran, P.N. 2003. *Cinnamon and cassi*a. CRC press.
38. Ravindran, P.N. 2004. *Ginger, the genus Zingiber*. CRC press.

39. Ravindran, P.N. 2007. *Turmeric, the genus curcuma*. CRC press. Medicinal and Aromatic Plants - Industrial Profiles. Routledge, UK.
40. Ravindran, P.N. 2001. *Monograph on Black Pepper*. CRC Press.
41. Ravindran, P.N. 2017. *The Encyclopedia of Herbs and Spices*. CABI.
42. Ravindran, P.N. and Madhusoodanan, K.J. 2002. *Cardamom, the Genus Elettaria*. CRC press.
43. Sera T., Soccol C.R., and Pandey A., Roussos S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
44. Sethuraj, M.R. and Mathew, N.T.1992. *Natural Rubber: Biology, Cultivation and Technology* (Developments in Crop Science). Elsevier Science.
45. Shanmugavelu, K.G., Kumar, N. and Peter, K.V. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.
46. Sharangi, A.B. 2018. *Indian Spices: The legacy, production and processing of India's treasured export*." Springer Int. Publishing. AG, Part of Springer Nature, 2018, Cham, Switzerland.
47. Sharangi, A.B., Datta, S., and Deb, P. 2018. *Spices: Agro techniques for quality produce*, April Academic Press ( Tylor and Francis Groups), New Jersey, USA
48. Srivastava, H.C, Vatsaya., and Menon, K.K.G. 1986. *Plantation Crops–Opportunities and Constraints*. Oxford and IBH.
49. Swain, S.C. 2018. *Precision farming in Horticulture: Approaches and str*ategies. Narendra Publishing House, New Delhi.
50. Thakur, R.S., Pauri, H.S., and Hussain, A. 1989. *Major Medicinal Plants of In*dia. CSIR.
51. Thampan, P.K. 1981. *Hand Book of Coconut Pa*lm. Oxford and IBH.
52. Varmudy, V. 2001. *Marketing of Spices*. Daya Publ. House.
53. Warrier, P.K., Nambiar, V.P.K., and Ramankutty, C. 2007. *Indian Medicinal Plants, a compendium of 500 species*. University Press (India) Private Ltd.
54. Winton, A.L. and Winton, K.B. 1931. *The Structure and Composition of Food*. John Wiley & Sons.
55. Yagna Narayan Ayer, A.K. 1960. *Cultivation of Cloves in India*. ICAR.

## PSM 622 ABIOTIC STRESS MANGEMENT IN PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS 3(2+1)

**WHY THIS COURSE?**

Global climate is undergoing drastic changes and crops find it difficult to adapt to the changed environments. Abiotic stress due to temperature, water, salts, radiations, nutrients, pollutants *etc.* affects the growth, physiology, yield and quality attributes of PSMA crops. This course is designed for the learner to understand the influence of these abiotic stress factors on PSMA crops.

**AIM OF THE COURSE**

The course aims to impart knowledge on the influence of abiotic stress factors on growth, physiology, yield and quality attributes of PSMA crops along with advanced approaches in the management of these stresses.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Abiotic Stress | 1. Temperature and water stress |
| | | 2. Stress due to soil conditions and salt |
| | | 3. Pollution stress |
| | | 4. Other stresses |
| 2. | Climate Change | 1. Contributing factors |
| | | 2. Carbon trading |
| | | 3. Impact of climate change on PSMA crops |
| 3. | Climate Resilient Technologies | 1. Varieties |
| | | 2. Climate resilient technologies |
| | | 3. Waste management |

**OUTCOME OF THE COURSE**

The learner is expected to get empowered on

1. the impact of abiotic stress on PSMA crop production
2. the mitigation measures to be adopted for sustaining PSMA crop production.

**THEORY**

**Block 1. Abiotic Stress**

Definition, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, *etc.*), salt stress

**UNIT-I:** *Temperature and water stress:* Stresses due to water (high and low), temperature (high and low), symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality

**UNIT-II:** *Stress due to soil conditions and salts:* Alkainity, salinity, iron toxicity, fertilizer toxicity symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality

**UNIT-III:** *Pollution stress:* Gaseous pollutants and heavy metals, symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality

**UNIT-IV:** *Other stresses:* Stress due to radiation, wind, nutrients. Symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality

**Block 2. Climate change**

**UNIT-I:** *Contributing factors:* Introduction to climate change, factors contributing to climate change, change in temperature, rainfall, humidity, rise in the atmospheric $CO_2$ levels, tropospheric ozone levels, extreme climatic events

**UNIT-II:** *Carbon trading:* Global warming, carbon trading, role of greenhouse gases and impact on productivity of PSMA crops. Clean development mechanism

**UNIT-III:** *Impact of climate change on PSMA crops*: Plantation crops, Spice crops, Medicinal and aromatic crops

**Block 3. Climate resilient technologies**

**UNIT-I:** *Varieties:* Plantation crops, Spice crops, Medicinal and aromatic crops

**UNIT-II:** *Climate resilient technologies:* Plantation crops, Spice crops, Medicinal and aromatic crops.

**UNIT-III:** *Waste management:* Alternate farming systems, Zero waste management, Microbial waste management

**PRACTICAL**

1. Analysis of plant stress factors;
2. Relative water content;
3. Chlorophyll stability index;
4. Plant waxes;
5. Stomatal diffusive resistance;
6. Transpiration;
7. Photosynthetic rates;
8. Calculation of water use efficiency and growth rates;
9. Identifying abiotic stress symptoms and injuries;
10. Use of antitranspirants;
11. Managing nutrient stress;
12. Stress management by hormones;
13. Screening for abiotic stress tolerance;
14. Weather data analyses and quantification of climate change;
15. Cropping pattern changes due to climate extremities;
16. Phenological and quality changes in PSMAs;
17. Pesticide residue analysis in PSMAs.

**SUGGESTED READINGS**

1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology*. CRC Press.
2. Ahmad, Parvaiz, M.N.V. and Prasad, 2012. *Abiotic Stress Responses in Plants Metabolism, Productivity and Sustainability*. Springer.

3. *E-manual on Advances in Cashew Production Technology*. ICAR- Directorate of Cashew Research, Puttur– 574 202, D.K., Karnataka.
4. Rao, H.C.P., Srinivas, N.K., Shivashankar, K.S. 2013. *Climate-Resilient Horticulture: Adaptation and Mitigation Strategies*. Springer.
5. Hebbar, K.B., Kumar, S.N., and Choudappa, P. 2017. *Impact of climate change on Plantation Crops*. Daya Publishing House, New Delhi.
6. Jenks, M.A. and Hasegawa, P.M. 2003. *Plant Abiotic Stress*. Black Well.
7. Levitt, J. 1972. *Response of Plants to Environmental Stresses*. Academic Press.
8. Manish, B. 2018. *Climate resilient agriculture: Adaptation, mitigation strategies*. New India Publishing Agency, New Delhi.
9. Mussell, H. and Staples, R. 1979. *Stress Physiology in Crop Plants*. Wiley Inter. Science.
10. Nickell, L.G. 1983. *Plant Growth Regulating Chemicals*. CRC Press.
11. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
12. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
13. Pillay, P.N.R. 1980. *Handbook of natural rubber production in India*. Rubber Research Institute, Kottayam. pp.668.
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15. Roy, B and Basu, A.K. 2009. *Abiotic stress tolerance in crop plants*. New India Publ. House.
16. Sera, T., Soccol, C.R., Pandey, A., and Roussos, S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
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18. Shanker, A. K. and Venkateswarlu, B. 2011. *Abiotic Stress in Plants– Mechanisms and Adaptations.* In tech, Croatia.
19. Turner, N.C. and Kramer, P.J. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley and Sons.
20. Venkateswarlu, B., Shanker, A.K., Chitra, M., and Maheswari, M. *Crop Stress and its Management: Perspectives and Strategies*. Springer.
21. www.plantphysiol.org, www.plantsress.com


## PSM 623 ADVANCES IN LABORATORY TECHNIQUES FOR PSMA CROPS 3(1+2)

**WHY THIS COURSE?**

Plantation, spice, medicinal and aromatic crops demand specific post-harvest management and value addition. At each step it has to undergo quality assessment using modern equipment and machinery. Export standards are also based on stringent quality parameters. This course is designed to make the learner well versed with modern analytical methods, instruments and machinery used in quality analyses.

**AIM OF THE COURSE**

To equip the students with the latest laboratory techniques required for assessing the quality of PSMA crops.

The course is organised as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Plantation Crops | 1. Physiological and biochemical changes |
| | | 2. Contaminants |
| | | 3. Value addition |
| 2. | Spice Crops | 1. Physiological and biochemical changes |
| | | 2. Contaminants |
| | | 3. Value addition |
| 3. | Medicinal and Aromatic Crops | 1. Secondary metabolites and their biosynthetic pathways |
| | | 2. Contaminants |
| | | 3. Value addition |

**COURSE OUTCOME**

After completion of this course, the student will be equipped in

1. the modern analytical methods of biochemistry
2. handling of equipments and machinery used in biotechnology, processing and value addition

**THEORY**

**Block 1. Plantation Crops**

**UNIT-I:** *Physiological and biochemical changes*: Physiological and biochemical changes during maturity and ripening including post-harvest changes. Factors influencing quality

**UNIT-II:** *Contaminants*: Adulterants, substitutes, sources of contamination: microbial, heavy metal, pesticide residues

**UNIT-III:** *Value addition*: Fixed oils, value added products, grading, storage, transportation Block

**Block 2. Spice Crops**

**UNIT-I:** *Physiological and biochemical changes*: Physiological and biochemical changes during maturity and ripening including Post harvest changes. Factors influencing quality

**UNIT-II:** *Contaminants*: Adulterants, substitutes, sources of contamination: microbial, heavy metal, pesticide residues

**UNIT-III:** *Value addition*: Fixed oils, essential oils, value added products, grading, storage, transportation.

**Block 3. Medicinal and aromatic crops**

**UNIT-I:** *Secondary metabolites* and their biosynthetic pathways, factors affecting production of secondary metabolites, changes during maturity, harvesting and processing

**UNIT-II:** *Contaminants*: Adulterants, substitutes, contamination: microbial, heavy metal, pesticide residues

**UNIT-III:** *Value addition*: Fixed oils, essential oils, oleoresins, concretes, absolutes, dyes, natural colours, aroma chemicals, grading, storage, transportation. Quality standards of raw materials and finished products

**PRACTICAL**

1. Sampling techniques in PSMA crops or their parts;
2. Solvent extraction of spices and medicinal plants;
3. Detection of adulterants and substitutes;
4. Extraction of secondary metabolites from medicinal crops;
5. Qualitative analyses of secondary metabolites;
6. Quantitative estimation of secondary metabolites;
7. Preparation of plant extracts;
8. Chromatographic separation of extracts;
9. Thin layer chromatography;
10. Soxhlet extraction;
11. Super critical fluid extraction;
12. Determination of physical and chemical properties of essential oils;
13. Flavour profile of essential oils by gas chromatography;
14. Chemical characterization by HPTLC;
15. Chemical characterization by GCMS;
16. Chemical characterization by LCMS;
17. Chemical characterization by NMR;
18. Bioassay and High Throughput Screening;
19. Techniques for assessment of antimicrobial property;
20. Techniques for assessment of antioxidant property, pesticide residue analyses;
21. Determination of heavy metals by flame photometry;
22. Plant tissue cultures in the industrial production of bioactive plant metabolites;
23. Exposure visit to leading medicinal and aromatic industries, accredited quality control labs.

**SUGGESTED READINGS**

1. Barche, S. 2016. *Production technology of spices, aromatic, medicinal and plantation crop*s. New India Publishing Agency, New Delhi.

2. Das, K. 2013. *Essential oils and their applications*. New India Publishing Agency, New Delhi.
3. Hammon, J.M. and Yusibov, V. 2000. *Plant Biotechnology: New Products and application*. Springer-Verlag.
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5. Raaman, N. 2006. *Phytochemical techniques*. New India Publishing Agency, New Delhi.
6. Ramawat, K.G. 2007. *Biotechnology: secondary metabolites: plants and microbes*. Science Publishers.
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8. Shankar, S.J. 2018. *Comprehensive post-harvest technology of flowers, medicinal and aromatic plants*. Narendra Publishing House, New Delhi.
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10. Parimelzhagan, T. 2013. *Turning plants into medicines: Novel approaches*. NIPA New Delhi.
11. Tiwari Chandra, 2018. *Antimicrobial properties of Medicinal plants*. Narendra Pub. H, New Delhi.
12. Trivedi, C. 2004. *Herbal drugs and biotechnology*. Pointer Publishers.
13. Waghulkar, V.M. 2012. *Quality assurance techniques in pharmaceutical*s. NIPA, New Delhi.

## PSM 624 BIOTECHNOLOGICAL APPROACHES IN PSMA CROPS 3(3+0)

**WHY THIS COURSE?**

Tools of biotechnology are widely used in crop improvement, crop management, crop protection and post-harvest management of PSMA crops. This course is designed to impart knowledge on advanced biotechnological tools used in various spheres of plantation, spices, medicinal and aromatic crops.

**AIM OF THE COURSE**

The main objective of the course is to impart to the learner, knowledge on advanced biotechnological tools used in various spheres of plantation, spices, medicinal and aromatic crops.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Plantation Crops | 1. *In vitro* mass multiplication techniques |
| | | 2. *In vitro* breeding |
| | | 3. Transgenic crops |
| 2. | Spice Crops | 1. *In vitro* mass multiplication techniques |
| | | 2. *In vitro* breeding |
| | | 3. Transgenic crops |
| 3. | Medicinal and Aromatic Crops | 1. *In vitro* mass multiplication techniques |
| | | 2. *In vitro* breeding |
| | | 3. Transgenic crops |
| | | 4. In vitro production of secondary metabolites |

**OUTCOME OF THE COURSE**

The learner is expected to be -
1. acquainted with the applications of biotechnology in PSMA crops
2. able to start modern labs based on biotechnology in PSMA crops

**THEORY**

**Block 1. Plantation Crops**

**UNIT-I:** *In vitro mass multiplication techniques*: In vitro conservation of plantation crops, direct and indirect organogenesis, micro grafting, hardening techniques

**UNIT-II:** *In vitro breeding*: Production of haploids, somaclones and identification of somaclonal variants, in vitro techniques to overcome fertilization barriers, protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species. In vitro mutation for biotic and abiotic stresses, disease elimination in crops.

**UNIT-III:** *Transgenic crops*: Recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology. Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars *etc.*, achievements, problems and future thrusts

**Block 2. Spice Crops**

**UNIT-I:** *In vitro mass multiplication techniques*: In vitro conservation of spice crops. Direct and indirect organogenesis, micro grafting, hardening techniques, production of micro rhizomes.

**UNIT-II:** *In vitro breeding*: Production of haploids, somaclones and identification of somaclonal variants, in vitro techniques to overcome fertilization barriers, Protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, in vitro mutation for biotic and abiotic stresses, disease elimination in crops

**UNIT-III:** *Transgenic crops*: Recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology. Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars *etc.*, achievements, problems and future thrusts

**Block 3. Medicinal and Aromatic Crops**

**UNIT-I:** *In vitro mass multiplication techniques*: In vitro conservation of medicinal and aromatic crops, direct and indirect organogenesis, micro grafting, hardening techniques and production of micro rhizomes.

**UNIT-II:** *In vitro breeding*: Production of haploids, somaclones and identification of somaclonal variants, in vitro techniques to overcome fertilization barriers, Protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, in vitro mutation for biotic and abiotic stresses, disease elimination in crops.

**UNIT-III:** *Transgenic crops*: Recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology. Role of molecular markers in characterization of transgenic crops, finger printing of cultivars *etc.*, achievements, problems and future thrusts

**UNIT-IV:** *In vitro production of secondary metabolites*: Invitro production and characterization of secondary metabolites, bioreactors.

**CROPS:**

Coconut, Rubber, Oil palm, Coffee, Tea, Cocoa, Black pepper, Cardamom, Turmeric, Ginger, Vanilla, Periwinkle, Rauvolfia, Mint, *Cymbopogon* grasses, Medicinal coleus, *Ocimum* sp., Aswagandha, Aloe, Safed musli, Stevia

**SUGGESTED READINGS**


1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology*. CRC Press.
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3. Bajaj, Y.P.S. (Ed.). 1987. *Biotechnology in Agriculture and Forestry*. Springer.
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9. Debnath, M. 2005. *Tools and Techniques of Biotechnology*. Pointer Publ.
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12. Glover, M.D. 1984. *Gene Cloning: The Mechanics of DNA Ma*nipulation. Chapman and Hall.
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16. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
17. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
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19. Parthasarathy, V.A., Bose, T.K., Deka, P.C., Das, P., Mitra, S.K., and Mohanadas, S. 2001. *Biotechnology of Horticultural Crops*. Vols. I-III. Naya Prakash.
20. Pierik, R.L.M. 1987. *In vitro Culture of Higher Plants*. Martinus Nijhoff Publ.
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22. Prasad S. 1999. *Impact of Plant Biotechnology on Horticulture*. 2nd Ed. Agro Botanica.
23. Sera, T., Soccol, C.R., Pandey, A., and Roussos, S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
24. Sethuraj, M.R. and Mathew, N.T. 1992. *Natural Rubber: Biology, Cultivation and Technology* (Developments in Crop Science). Elsevier Science.
25. Sharma, R. 2000. *Plant Tissue Culture*. Campus Books, International.
26. Shukla, Y.M. 2009. *Plant secondary metabolites*. New India Publishing Agency, New Delhi.
27. Singh, B.D. 2001. B*iotechnology*. Kalyani.
28. Skoog, F. and Miller, C.O. 1957. *Chemical Regulation of Growth and Formation in Plant Tissue Culture in vitro*. Symp. Soc. Exp. Biol. 11, 118-131.
29. Williamson, R. 1981-86. *Genetic Engineering*. Vols. I-V. Academic Press.

## PSM 625 ORGANIC SPICE AND PLANTATION CROPS PRODUCTION 3(2+1)

**WHY THIS COURSE?**

A shift to organic agriculture is happening in different parts of the world. Demand for organic plantation and spice crops is also increasing globally. This course is designed to give comprehensive knowledge on scientific organic farming technology in plantation and spice crops.

**AIM OF THE COURSE**

To impart knowledge on principles, concepts, techniques and certification procedures of organic farming in spice and plantation crops.

The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Concepts of Organic Farming | 1. Importance |
| | | 2. Organic conversion plan |
| | | 3. Organic farming systems |
| 2. | Organic Production Technologies | 1. Plantation crops |
| | | 2. Major spices |
| | | 3. Minor spices |
| 3. | Certification and Quality Control | 1. Accreditation |
| | | 2. Organic standards |
| | | 3. Quality control |

**OUTCOME OF THE COURSE**

The learner is expected to get empowered on

1. the organic farming techniques in Spice and Plantation crops
2. the organic certification procedures in Spice and Plantation crops

**THEORY**

**Block 1. Concepts of Organic Farming**

**UNIT-I:** *Importance:* Principles, perspectives, concepts and components of organic farming, present status of organic farming at national and global level, domestic and global demand for organic products with respect to spice and plantation crops, organic production and export - opportunities and challenges

**UNIT-II:** *Organic Conversion Plan:* Advanced methods for enhancing soil fertility, soil amendments. Modern methods of composting, vermicomposting, coir pith composting, bio fertilizers, pest and disease management in organic farming; crop rotation in organic horticulture, weed management, botanicals and bio- control agents

**UNIT-III:** *Organic Farming Systems:* Natural farming, permaculture, biodynamic farming, Zero budget farming, Homa farming, EM technology

**Block 2. Organic Production Technology**

**UNIT-I:** *Plantation crops:* Coconut, Coffee, Cocoa, Tea

**UNIT-II:** *Major Spices:* Black pepper, Cardamom, Ginger, Turmeric, Vanilla

**UNIT-III:** *Seed spices:* Coriander, Cumin, Fennel, Fenugreek

**Block 3. Certification and Quality Control**

**UNIT-I:** *Accreditation:* Accreditation agencies, certification agencies, procedure of certification, types of certification

**UNIT-II:** *Organic standards:* Domestic and international standards, NPOP, IFOAM, CODEX, HACCP standards

**UNIT-III:** *Quality control:* Participatory Guarantee System (PGS) in quality control, quality control for organic products

**PRACTICAL**

1. Enrichment of composts;
    a. Biofertilizers
    b. Bio control agents
2. Biodynamic preparations;
3. Zero- budget preparations;
4. Biopesticides;
5. AMF in organic production;
6. Waste management techniques;
7. Exposure visits to organic fields, certification and marketing centres.

**SUGGESTED READINGS**


1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Technology*. CRC Press.
2. Dahama, A.K. 2005. *Organic Farming for Sustainable Agriculture*. 2nd Ed. Agrobios.
3. *E-manual on Advances in Cashew Production Technology*. ICAR- Directorate of Cashew Research, Puttur –574 202, D.K., Karnataka.
4. Gehlot, G. 2005. *Organic Farming: Standards, Accreditation, Certification and Inspection*. Agrobios.
5. Palaniappan, S.P. and Annadarai, K. 2003. *Organic Farming: Theory and Practice*. Sci. Publ.
6. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
7. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
8. Parthasarthy, V.A., Kandiannan, V. and Srinivasan, V. 2008. *Organic Spices*. NIPA.
9. Pradeepkumar, T., Suma, B., Jyothibhaskar and Satheesan, K.N. 2008. *Management of Horticultural Crops*. New India Publ. Agency.
10. Sera, T., Soccol, C.R., Pandey, A., Roussos, S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
11. Shivashankar, K. 1997. *Food Security in Harmony with Nature*. 3, IFOAM- RD, ASIA, Scientific Conference. 1-4 Dec., 1997, UAS, Bangalore.


## PSM 626 MARKETING AND TRADE OF PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS 3(2+1)

**WHY THIS COURSE?**

Marketing and trade are two important aspects in the domestic as well as international movement of PSMA crops. Instability in the price structure as well as demand of various plantation and spice crops often puts the farmers and entrepreneurs at risk. This course is designed to impart in the learner a deeper understanding on marketing and trade in raw materials and value added products of PSMAs crops both at the domestic and international level.

**AIM OF THE COURSE**

This **course** is designed to impart in the learner a deeper understanding on marketing and trade in raw materials and value added products of PSMAs crops both at the domestic and international level.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Importance of Marketing and Trade | 1. Market opportunities |
| | | 2. Marketing strategies |
| 2. | Marketing Channels | 1. Market organisations |
| | | 2. Value chain management and total quality management |
| 3. | Entrepreneurship Development | 1. Decision making |
| | | 2. Price structure |

**OUTCOME OF THE COURSE**

The learner is expected to get empowered on

1. the marketing and trade opportunities and channeless in PSMA crops
2. the entrepreneurship development and value chain in PSMA crops
3. decision support and pricing system in PSMA crops

**Block 1. Importance of marketing and trade**

**UNIT-I:** *Market opportunities:* Market opportunities and challenges in PSMA crops at the domestic and global level, consumption in India's plantation, herbal and spice and other industries, Demand-supply scenario of PSMAs at the national and international level, Marketing and trade in raw materials and value added products

**UNIT-II:** *Marketing strategies*: Direct and indirect marketing, niche marketing, specialty markets, market intermediaries and their role, market infrastructure needs, marketing efficiency. market organization, planning, promotion, cost control, contract farming

**Block 2. Marketing Channels**

**UNIT-I:** *Market organizations:* Marketing co-operatives including tribal co- operatives, public private partnerships (PPP), Farmer Producer Companies (FPC) and Farmer Producer Organisations (FPOs).

**UNIT-II:** *Supply chain management and total quality management:* Good transportation procedures, cold storage facilities, State trading, warehousing and other govt. agencies. Role of commodity boards and export promotion councils in marketing and export of PSMA crops

**Block 3. Entrepreneurship development**

**UNIT-I:** *Decision making:* Risk taking, motivation, importance of planning, monitoring, evaluation and follow up, SWOT analysis, generation, incubation and commercialisation of ideas and innovations. Communication skills, domestic and export market intelligence, export standards .Role of information technology and telecommunication in marketing of PSMAs

**UNIT-II:** *Price structure:* Price analysis and price forecasting in PSMA crops, policies on export, import and re-export of commodities and value added products, guidelines for marketing of organic produce and organic products

**PRACTICAL**

1. Study of requirement of various raw materials by the plantation, spice and ayurveda industries;
2. Demand supply analysis of various PSMA crops;
3. Exposure visit to trading centres, exporters, ware houses, value addition units *etc.*;
4. Study of FPOs and FPCs in various crops;
5. Preparation and evaluation of projects;
6. Documentation of case studies.

**SUGGESTED READINGS**

1. Afoakwa, E.O. 2016. *Cocoa Production and Processing Techn*ology. CRC Press.

2. Chinnappa, B. 2018. *Economics and marketing of Arecanut in India*. Narendra Pub. H New Delhi.
3. CUTS, 2004. *Data base on Medicinal Plants*. CUTS Centre for International Trade, Economics and Environment, Calcutta.
4. *E-manual on Advances in Cashew Production Technology*. ICAR- Directorate of Cashew Research, Puttur –574 202, D.K., Karnataka.
5. Holly, J. and Cheria, K. 1998. *The medicinal plant Sector in India*. Medicinal and Aromatic Programme in Asia (MAPPA), New Delhi, India.
6. https://www.nmpb.nic.in
7. Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
8. Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
9. Pillay, P.N.R. 1980. *Handbook of natural rubber production in India*. Rubber Research Institute, Kottayam. pp.668.
10. Sera, T., Soccol, C.R., Pandey. A., Roussos, S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
11. Sethuraj, M.R. and Mathew, N.T. 1992. *Natural Rubber: Biology, Cultivation and Technology* (Developments in Crop Science). Elsevier Science.
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13. Varmudi, 2001. *Marketing of Spices*. Daya publishing house.
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# COURSE CONTENTS: M.Sc. (Hort.) FLORICULTURE AND LANDSCAPING

## FLS 511 BREEDING OF ORNAMENTAL CROPS 3(2+1)

**WHY THIS COURSE?**

Breeding novel and desired varieties is very important for growth of floriculture Industry. Students should have a thorough understanding of principles of plant breeding, genetic mechanisms and breeding methods in ornamental crops for making improvement in these crops.

**AIM OF THIS COURSE**

To impart comprehensive knowledge about the principles and practices of breeding of ornamental plants.

The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Principles of Plant Breeding | 1. Principles of plant breeding |
| | | 2. Intellectual Property and Plant Breeders Rights |
| | | 3. Genetic mechanisms and inheritance |
| 2. | Breeding methods | 1. Breeding methods |
| | | 2. Role of biotechnology |

**COURSE OUTCOME**

After successful completion of course, the students are expected to have

1. Thorough understanding of principles of plant breeding and genetic mechanisms in different ornamental plants and flowers.
2. Application of different breeding methods for improvement of ornamental crops
3. Develop the required skills in conventional and advanced breeding

**THEORY**

**Block 1: Principles of Plant Breeding**

**UNIT-I:** *Principles of plant breeding*: Principles of plant breeding; Origin, evolution, distribution, introduction, domestication and conservation of ornamental crops

**UNIT-II:** *Intellectual Property and Plant Breeders Rights*: Introduction and initiatives in IPR and PBR of ornamental crops.

**UNIT-III:** *Genetic mechanisms and inheritance*: Breeding objectives, reproductive barriers (Male sterility, incompatibility) in major ornamental crops. Inheritance of important traits, Genetic mechanisms associated with flower colour, size, form, doubleness, fragrance, plant architecture, post-harvest life, abiotic and biotic stress tolerance/ resistance.

**Block 2: Breeding methods**

**UNIT-I:** *Breeding methods*: Breeding methods suitable for sexually, asexually propagated flower crops, self and cross pollinated crops- pedigree selection, backcross, clonal selection, polyploidy and mutation breeding, heterosis and F1 hybrids.

**UNIT-II:** *Role of biotechnology*: Role of biotechnology in improvement of flower crops including somaclonal variation, in vitro mutagenesis, in vitro selection, genetic engineering, molecular markers *etc.*,

**Crops:** Rose, chrysanthemum, carnation, gerbera, gladiolus, orchids, anthurium, lilium, marigold, jasmine, tuberose, dahlia, gaillardia, crossandra, aster *etc.*, Flowering annuals: petunia, zinnia, snapdragon, stock, pansy, calendula, balsam, dianthus *etc*. Important ornamental crops like aglaonema, diffenbachia, hibiscus, bougainvillea, kalanchoe *etc*.

**PRACTICAL**

1. Floral biology of important ornamental crops (2)
2. Cytology and cytogenetics (2)
3. Selfing and crossing procedures for important ornamental crops (2)
4. Evaluation of hybrid progenies (2)
5. Induction of mutants through physical and chemical mutagens (2)
6. In vitro selection, genetic engineering (2)

7. Induction of polyploidy (2)
8. DUS testing (2)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and student presentation
- Hands on training of different procedures

**SUGGESTED READINGS**


1. Vainstein, A. (Ed). 2002. *Breeding for ornamental crops: Classical and Molecular Approaches*. Springer-Science-Business Media, B.V. Edition 1. pp. 392.
2. Bhattacharjee, S.K. 2018. *Advances in Ornamental Horticultu*re. Pointer Publ., Reprint, 6 vols, pp. 2065.
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4. Callaway, D.J. & Callaway, M. B. 2009. *Breeding Ornamental Plants*. Timber Press. Revised edition, pp. 359.
5. Chadha, K.L. & Bhattacharjee, S.K. 1995. *Advances in Horticulture: Ornamental Plants*. Vol. XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India.
6. Chadha, K.L. & Choudhury, B.1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
7. Chaudhary, R.C. 1993. *Introduction to Plant Breeding*. Oxford & IBH Publ.
8. Misra, R.L. & Misra, S. 2017. *Commercial Ornamental Crops: Cut Flowers*. Kruger Brentt Publisher UK Ltd. pp.584.
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10. Singh, B. D. 2016. *Plant Breeding Principles and Methods*. Kalyani Publishers, New Delhi-Ludhiana, India.
11. Watts, L. 1980. *Flower and Vegetable Plant Breeding*. Unilever Research, Sharnbrook, Bedford, UK. pp 182. Grower Books, London, UK.


## FLS 512 ORNAMENTAL GARDENING AND LANDSCAPING 3(2+1)

**WHY THIS COURSE?**

Ornamental gardening and landscaping is an important course which gives a thorough understanding of different types of gardens and their components. The students need to imbibe the principles of landscaping and should develop skills for planning under different situations.

**AIM OF THIS COURSE**

Familiarization with principles and practices of landscaping

The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Gardens and components | Styles and types of gardens |
| | | Garden components |
| | | Specialized gardens |
| 2. | Landscape planning | Principles and elements of landscaping |
| | | Landscaping for different situations |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be

1. The students will be apprised of different types of gardens and have a thorough understanding of principles of landscape gardening
2. Develop skills for landscaping under different situations and layout of garden components.

**THEORY**

**Block 1: Gardens and components**

**UNIT-I:** *Styles and types of gardens:* Historical background of gardening, Importance and scope of ornamental gardening, styles and types of gardens, formal and informal style gardens. English, Mughal, Japanese, Persian, Spanish, Italian, French, Hindu and Buddhist gardens.

**UNIT-II:** *Garden components:* Garden components (living and non-living): arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, colour wheels , clock garden, bamboo groves, bonsai; Non -living components like- path, garden gate, fencing, paving and garden features like fountains, garden seating, swings, lanterns, basins, bird baths, sculptures, waterfalls, bridge, steps, ramps, Lawn -genera and species, establishment and maintenance.

**UNIT-III:** *Specialized gardens:* Specialised gardens such as vertical garden, roof garden, terrace garden, water garden, sunken garden, rock garden, shade garden, temple garden, sacred gardens (with emphasis on native plants), Zen garden.

**Block 2: Landscape planning**

**UNIT-I:** *Principles and elements of landscaping:* Basic drawing skills, use of drawing instruments garden symbols, steps in preparation of garden design, programmes phase, design, phase, *etc*. Elements and principles of landscape design. Organization of spaces, visual aspects of plan arrangement- view, vista and axis. Principles of circulation, site analysis and landscape, water requirement, use of recycled water

**UNIT-II:** *Landscaping for different situations*: Urban landscaping, Landscaping for specific situations such as residential, farm houses, institutions, corporate sector, industries, hospitals, roadsides, traffic islands, Children parks, public parks, xeriscaping, airports, railway station and tracks, river banks and dam sites and IT/ SEZ parks. Bio-aesthetic planning, ecotourism, theme parks, indoor gardening, therapeutic gardening,

**PRACTICAL (16)**

1. Graphic language and symbols in landscaping, study of drawing instruments viz., 'T' square, setsquare, drawing board, *etc*. (1)
2. Identification of various types of ornamental plants for different gardens and occasions (1)
3. Preparation of land, planning, layout and planting, deviations from landscape principles (1)
4. Case study (1)
5. Site analysis, interpretation of map of different sites, use of GIS for selection (1)
6. Enlargement from blue print. Landscape design layout and drafting on paper as per the scale (2)
7. Preparation of garden models for home gardens, farm houses, industrial gardens, institutional gardens, corporate, avenue planting, practices in planning and planting of special types of gardens.(3)
8. Burlapping, lawn making, planting of edges, hedges, topiary, herbaceous and shrubbery borders (2)
9. Project preparation on landscaping for different situations, creation of formal and informal gardens (2)
10. Visit to parks and botanical gardens (2)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training on different models of landscaping
- Exposure visits

**SUGGESTED READINGS**

1. Bose, T.K., Chowdhury, B. & Sharma, S.P. 2011. *Tropical Garden Plants in Colour*. Hort. and Allied Publ.
2. Bose, T.K., Maiti, R.G., Dhua, R.S. & Das, P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.
3. Grewal, H.S. & Singh, P. 2014. *Landscape Designing and Ornamental Plants*. Kalyani Publ.
4. Lauria, A. & Victor, H.R. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur.
5. Misra, R.L. &Misra, S. 2012. *Landscape Gardening*. Westville Publ. House, New Delhi.

6. Nambisan, K.M.P.1992. *Design Elements of Landscape Gardening*. Oxford & IBH Publ. Co., New Delhi.
7. Randhawa, G.S. & Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publ.
8. Sabina, G.T. & Peter, K.V. 2008. *Ornamental Plants for Gardens*. NIPA, New Delhi.
9. Singh, A. & Dhaduk, B. K. 2015. *A Colour Handbook: Landscape Gardening*. NIPA, New Delhi.
10. Valsalakumari, P.K., Rajeevan, P.K., Sudhadevi, P.K. & Geetha C.K. 2008. *Flowering Trees*. New India Publ. Agency, New Delhi
11. Woodrow, M. G.1999. *Gardening in India*. Biotech Books, New Delhi.

## FLS 513 COMMERCIAL PRODUCTION OF LOOSE FLOWERS 3(2+1)

**WHY THIS COURSE?**

Loose flowers are grown in a wide range of agroclimatic regions. The students of floriculture need to have an understanding of production and post-harvest management of important loose flower crops.

**AIM OF THIS COURSE**

To impart basic knowledge about the importance and management of loose flowers grown in India. The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Production management | 1. Scope and scenario |
| | | 2. Growing environment |
| | | 3. Crop management |
| | | 4. Flower regulation |
| 2. | Post-harvest management and marketing | 1. Post-harvest management |
| | | 2. Marketing |

**COURSE OUTCOMES**

After successful completion of this course, the students would have
1. A thorough understanding of production and post-harvest management of loose flowers.
2. Develop the required skills on commercial production management

**THEORY**

**Block 1: Production management**

**UNIT-I:** *Scope and scenario*: Scope, scenario and importance of loose flowers, constraints and opportunities in loose flower production

**UNIT-II:** *Growing environment*: Nursery management, pro-tray nursery under shade nets, soil and climate requirement, Field preparation, systems of planting.

**UNIT-III:** *Crop management*: Soli analysis, soil health card, water and nutrient management, weed management, training and pruning, special horticultural practices such as pinching and disbudding, use of growth regulators, physiological disorders and remedies, INM, IPM and IDM.

**UNIT-IV:** *Crop regulation*: Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation.

**Block 2: Post harvest management and marketing**

**UNIT-I:** *Post harvest management*: Harvest indices, harvesting techniques, post-harvest handling and grading, pre-cooling, packaging and storage

**UNIT-II:** *Marketing*: Important local markets, Export potential, transportation and marketing, APMC and online trading, institutional support, Crop Insurance

**Crops:** Rose, jasmine, chrysanthemum, marigold, tuberose, China aster, crossandra, gaillardia, spider lily, hibiscus, Nerium, barleria, celosia, gomphrena, Madar (*Calotropis gigantea*), nyctanthes (Harsingar), Ervatamia (Chandni), ixora, lotus, water lily, Michelia (Champa), gardenia, Ixora and balsam.

**PRACTICAL (16)**

1. Identification of species and varieties (1)

2. Propagation and nursery management (1)
3. Training and pruning techniques (1)
4. Fertigation, foliar nutrition, growth regulator application (2)
5. Crop protection (2)
6. Pinching, disbudding, staking, harvesting techniques (1)
7. Post-harvest handling, storage and cold chain (2)
8. Project preparation for regionally important commercial loose flowers. crop specific guidelines for project financing (NHB guidelines) (2)
9. Cost Economics (2)
10. Exposure Visits to fields (2)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**


1. Arora, J.S. 2010. *Introductory Ornamental Horticulture*. Kalyani Publi. 6th Edition, pp. 230.
2. Bhattacharjee, S.K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
3. Bose, T.K. Maiti, R.G., Dhua, R.S. & Das, P. 1999. *Floriculture and landscaping*. Naya Prokash, Kolkata, India.
4. Bose, T.K. & Yadav, L.P. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.
5. Chadha, K.L. & Bhattacharjee, S.K. 1995. *Advances in Horticulture: Ornamental Plants*. Vol. XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India.
6. Chadha, K.L. & Chaudhury, B.1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
7. Laurie, A. & Rees, V.H. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur. pp.534.
8. Prasad, S. & Kumar, U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur.
9. Randhawa, G.S. & Mukhopadhyay, A. 2001. *Floriculture in India*. Allied Publ. pp 660.
10. Sheela, V.L.2008. *Flowers for Trade.* Horticulture Science Series, vol.10, pp. 392. NIPA, New Delhi


## FLS 521 PROTECTED CULTIVATION OF FLOWER CROPS 3(2+1)

**WHY THIS COURSE?**

Protected cultivation is more rewarding in production of high value cut flowers. With appropriate structures and plant environment control measures, the constraints of environment prevalent in the region can be overcome allowing almost year-round cultivation.
The students need a thorough understanding of principles, types, designs, crops for different environments and management of environment in protected cultivation.

**AIM OF THIS COURSE**

Understanding the principles, theoretical aspects and developing skills in protected cultivation of flower crops.
The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Principles and types | 1. Prospects and types of protected structures |
| | | 2. Principles and designs |
| 2. | Growing Environment | 1. Control of environment |
| | | 2. Crop management and crop regulation |
| | | 3. Automation and standards |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be acquire

1. Knowledge on types, design and principles of protected structures
2. Thorough understanding of principles of microclimate management and crop management.
3. Develop the required skills for designing a greenhouse
4. Acquire skills on microclimate management, production management.

**THEORY**

**Block 1: Principles and types**

**UNIT-I:** *Prospects and types of protected structures*: Prospects of protected floriculture in India; Types of protected structures – Glasshouse/polyhouse, shade net houses, mist chambers, lath houses, orchidarium, fernery, rain shelters *etc.*, ,

**UNIT-II:** *Principles and design*: Principles of designing and erection of protected structures; Low cost/Medium cost/High cost structures; Location specific designs; Structural components; Suitable flower and foliage plants for protected cultivation.

**Block 2: Growing environment**

**UNIT-I:** *Control of environment*: Microclimate management and manipulation of temperature, light, humidity, air and CO2; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation, water harvesting,

**UNIT-II:** *Intercultural operations and crop regulation*: Containers and substrates, media, soil decontamination, layout of drip and fertigation system, water and nutrient management, IPM and IDM, Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, *etc.*); Staking and netting, Photoperiod regulation.

**UNIT-III:** *Automation and standards*: Automation in greenhouses, sensors, solar greenhouses and retractable greenhouses, GAP/Flower labels, Export standards, EXIM policy, APEDA regulations for export, Non-tariff barriers.

**Crops:** Rose, Chrysanthemum, Carnation, Gerbera, Orchids, Anthuriums, Lilium, Limonium, Lisianthus, heliconia, Cala lily, Alstromeria, *etc.*,

**PRACTICAL (16)**

1. Study of various protected structures (1)
2. Design, layout and erection of different types of structures (2)
3. Practices in preparatory operations, growing media, soil decontamination techniques (2).
4. Microclimate management (2)
5. Practices in drip and fertigation techniques, special horticultural practices (2).
6. Determination of harvest indices and harvesting methods (1)
7. Postharvest handling, packing methods (1)
8. Economics of cultivation, Project preparation (2)
9. Project Financing guidelines (1)
10. Visit to commercial greenhouses (2)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**

1. Bhattacharjee, S.K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
2. Bose, T.K., Maiti, R.G., Dhua, R.S. & Das, P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.
3. Bose, T.K. & Yadav, L.P. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.
4. Chadha, K.L. & Bhattacharjee, S.K. 1995. *Advances in Horticulture: Ornamental Plants*. Vol. XII, Parts 1 & 2. pp.533 & pp.574. Malhotra Publ. House, New Delhi, India.

5. Lauria, A. & Victor, H.R. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur.
6. Nelson PV. 2011. *Green House Operation and Management*. Pearson Publ. 7th edition
7. Prasad, S. & Kumar, U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur.
8. Randhawa, G.S. & Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publ.
9. Reddy, S., Janakiram, T., Balaji T., Kulkarni, S. &Misra, R. L. 2007. *Hi- Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi, India.


## FLS 522 NURSERY MANAGEMENT FOR ORNAMENTAL PLANTS 3(2+1)

**WHY THIS COURSE?**

Nursery management is very essential for production of quality planting material in ornamental plants. The course gives a thorough understanding of propagation of different ornamental plants, nursery management, standards, law and certification.

**AIM OF THIS COURSE**

Familiarization with principles and practices of propagation and nursery management for Ornamental plants.

The course is organized as follows:

| No. | Blocks | Units |
|---|---|---|
| 1. | Nursery Industry and Propagation | 1. Scenario of nursery industry and sexual propagation |
| | | 2. Asexual propagation |
| | | 3. Micropropagation |
| 2. | Nursery Management | 1. Growing structures |
| | | 2. Sanitary and phytosanitary issues |
| | | 3. Standards |

**COURSE OUTCOMES**

After successful completion of this course,

1. The students will develop thorough understanding of nursery management in flower crops.
2. Empower the students with the knowledge to start an enterprise
3. Hone adequate skill in propagation and management

**THEORY**

**Block 1: Nursery Industry and Propagation**

**UNIT-I:** *Scenario of nursery industry and sexual propagation:* Importance and present scenario and status of nursery industry in India and in the world , life cycles in plants, Propagation methods, Factors influencing seed germination of flower crops, dormancy, seed quality, packing, storage, certification, testing. Hormonal regulation of germination and seedling growth.

**UNIT-II:** *Asexual propagation:* Methods of asexual propagation, rooting of soft and hard wood cutting under mist. Role of Plant growth regulators. Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principles and methods, budding and grafting – selection of elite mother plants. Stock, scion and inter stock, relationship – Incompatibility,

**UNIT-III:** *Micropropagation:* Micro-propagation – principles and concepts, commercial exploitation in flower crops. Techniques - in vitro clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture. Hardening, packing and transport of micropropagules.

**Block 2: Nursery Management**

**UNIT-I:** *Growing structures:* Growing structures like mist chambers, tunnels, lath house, net house, growing media types, soil less culture and containers. Automation in nursery management.

**UNIT-II:** *Sanitary and phyto-sanitary issues:* Nursery – types, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, PPV&FR act and Quarantine system in India. Important quarantine pests and diseases, sanitary and phyto-sanitary issues threats to nursery Industry.

**UNIT**-III: *Standards:* Nursery standards, Hi-tech nurseries, garden centres.

**PRACTICAL (16)**

1. Anatomical studies in rooting of cutting and graft union (2)
2. Identification and production of plug plants, seedlings and saplings (2).
3. Preparation of growing media and use of PGRs (2).
4. Practice of propagation through specialized structures cuttings, layering, budding and grafting (2)
5. Case studies (2).
6. Micropropagation of ornamental crops and hardening (3).
7. Visit to tissue culture labs and nurseries (2)
8. Economics (1)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**

1. Adriance, G.W. & Brison, F.R. 2000. *Propagation of Horticultural Plants*. Biotech Books, New Delhi, India.
2. Bose, T.K., Mitra, S.K. & Sadhu, M.K. 1991. *Propagation of Tropical and Subtropical Horticultural Crops.* Naya Prokash, Kolkata, India.
3. Chadha, K.L., Ravindran, P.L. & Leela Sahijram. 2000. *Biotechnology in Horticulture and Plantation Crops*. Malhotra Publ. House, New Delhi.
4. Davies, Fred T. Jr., Geneve, R.L., Wilson, S.B., Hartmann, H.T. & Kester, D.L. 2018. *Hartmann and Kester's Plant Propagation: Principles and Practices*. Pearson Publ. 9th Edition.
5. Peter, K.V. 2008. *Basics of Horticulture*. New India Publ. Agency, New Delhi.
6. Rajan, S. & Baby, L.M. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency, New Delhi. pp. 251.
7. Singh, S.P. 1989. *Mist Propagation*. Metropolitan Book Co., New Delhi, India.

## FLS 523 SYSTEMATICS OF ORNAMENTAL PLANTS 2(1+1)

**WHY THIS COURSE?**

Systematics of ornamental plants will give an in depth knowledge on nomenclature, description of genera, floral biology and use of molecular techniques in systematics of flower crops and ornamental crops.

**AIM OF THIS COURSE**

To familiarize students about the taxonomy, classification, nomenclature and descriptors of different ornamental crops.

The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1 | Nomenclature | **UNIT-**1: History, origin, hotspots, classification and nomenclature systems<br>**UNIT-**2: International Code, Identification features, descriptors<br>**UNIT-**3: Red Book, Registration with NBPGR, PPVFRA |
| 2 | Families | **UNIT-**1: Rosaceae, Asteraceae, Caryophyllaceae, Orchidaceae, Aracaeae, Liliacaeae,<br>**UNIT-**2: Acanthaceae, Palmaceae, Asparagaceae, Malvaceae, Musaceae, Oleaceae, Iridaceae. |
| 3 | Molecular techniques | **UNIT-**1: Molecular techniques in modern systematics. |

**COURSE OUTCOME**

After successful completion of this course,

1. The students will have an in depth knowledge of nomenclature, description of important genera and use of molecular techniques in systematics of flower crop.

**THEORY**

**Block I: Nomenclature**

**UNIT-I:** *Nomenclature*: History, origin, hotspots, classification and nomenclature systems

**UNIT-II:** *International systems*: International Code, Treaties, International and National Organisations, Biodiversity Act, Identification features, descriptors.

**UNIT-III:** Red Book, Registration (NBPGR, PPVFRA, NBA)

**Block 2: Families**

**UNIT-I:** *Families*: Description and families and important genera Rosaceae, Asteraceae, Caryophyllaceae, Orchidaceae, Aracaceae, Liliacae,

**UNIT-II:** Acanthaceae, Palmaceae, Asparagaceae, Malvaceae, Musaceae, Oleaceae, Iridaceae.

**Block 3: Molecular techniques**

**UNIT-I:** Molecular techniques in modern systematics

**PRACTICAL (16)**

1. Different nomenclature systems of plants (2)
2. Floral biology and taxonomic description of rose, chrysanthemum, orchids, carnation, gerbera, anthurium, marigold, tuberose, Jasmine, China aster, lilium, gypsophila (6).
3. Cryopreservation and tissue culture repository (4)
4. Molecular techniques (4)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and student presentation
- Hands on training of different procedures

**SUGGESTED READINGS**


1. Bhattacharya, B. & Johri, B.M. 2004. *Flowering Plants: Taxonomy and Phylogeny.* Narosa Publ. House, New Delhi, India. pp.753.
2. Dutta, A.C. 1986. *A Class Book of Botany*. Oxford Univ. Press, Kolkata, India.
3. Pandey, B.P. 2013. *Taxonomy of Angiosperms*. S. Chand & Co. pp. 608.
4. Rajput, C.B.S. &Haribabu, R.S. 2014. *Citriculture.* Kalyani Publ., New Delhi, India.
5. Spencer, R.R., Cross, R. & Lumley, P. 2007. *Plant Names. 3rd Ed. A Guide to Botanical Nomenclature.* CSIRO Publ., Australia., 176 p.
6. Vasistha, B.B. 1998. *Taxonomy of Angiosperms*. Kalyani Publ., New Delhi, India.


## FLS 524 COMMERCIAL PRODUCTION OF CUT FLOWERS 3(2+1)

**WHY THIS COURSE?**

Cut flowers are grown in a wide variety of environments and agroclimatic regions. The students of floriculture need to have an understanding of production and post-harvest management of important cut flower crops on a commercial scale.

**AIM OF THIS COURSE**

To impart basic knowledge about the importance and production dynamics of cut flowers grown in India.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Production management | Scope and scenario |
| | | Growing environment |
| | | Crop Management |
| | | Flower regulation |
| 2. | Post-harvest management and marketing | Post-harvest management |
| | | Marketing |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be

1. Understand the scope and scenario of floriculture
2. A thorough understanding of production and post-harvest management of flower crops.
3. Acquire the required skills to prepare project reports on different crops for financing.

**THEORY**

**Block 1: Production management**

**UNIT-I:** *Scope and scenario:* National and International scenario, importance and scope of cut flower trade, constraints for cut flower production in India.

**UNIT-II:** *Growing environment:* Soli analysis, soil health card, Growing environment, open cultivation, protected cultivation, soil/media requirements, land preparation, planting methods, influence of light, temperature, moisture, humidity and microclimate management on growth and flowering.

**UNIT-III:** *Crop management*: Commercial Flower production – Commercial varieties, water and nutrient management, fertigation, weed management, crop specific practices, ratooning, training and pruning, pinching, deshooting, bending, desuckering, disbudding. Use of growth regulators, physiological disorders and remedies, IPM and IDM.

**UNIT-IV:** *Flower regulation*: Flower forcing and year round/offseason flower production through physiological interventions, chemical regulation, environmental manipulation.

**Block 2: Post harvest management and marketing**

**UNIT-I:** *Post harvest management*: Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Precooling, pulsing, packing, storage and transportation.

**UNIT-II:** *Marketing:* Marketing, export potential, institutional support, Agri Export Zones, 100% Export Oriented units, Crop Insurance

**Crops:** Rose, chrysanthemum, gladiolus, tuberose, carnation, gerbera, orchids, lilium, anthurium, China aster, alstroemeria, bird of paradise, heliconia, alpinia, ornamental ginger, dahlia, gypsophila, solidago, limonium, stock, cut greens and fillers.

**PRACTICAL (16)**

1. Identification of varieties (1)
2. Propagation (2)
3. Microclimate management (2)
4. Training and pruning techniques (1)
5. Pinching, deshooting, disbudding, desuckering (1)
6. Practices in manuring, drip and fertigation, foliar nutrition, growth regulator application (2)
7. Harvesting techniques, post-harvest handling, cold chain (2)
8. Economics, Project preparation for regionally important cut flowers, crop specific guidelines for project financing (NHB guidelines) (2)
9. Visit to commercial cut flower units (2)
10. Case studies (1)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and student presentation
- Hands on training of different procedures
- Exposure visits

**SUGGESTED READINGS**

1. Arora, J.S. 2010. *Introductory Ornamental Horticulture*. Kalyani Publishers. 6th edition, pp. 230.
2. Bhattacharjee, S.K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.

3. Bose, T.K., Maiti, R.G., Dhua, R.S. & Das, P. 1999. *Floriculture and Landscaping*. Prokash, Kolkata, India.
4. Bose, T.K. & Yadav, L.P. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.
5. Chadha, K. L. & Bhattacharjee, S.K. 1995. *Advances in Horticulture*: *Ornamental Plants*. Vol. XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India.
6. Chadha, K.L. & Chaudhury, B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
7. Dole, J. M. & Wilkins, H. F. 2004. *Floriculture-Principles and Species*. Prentice Hall. 2nd ed, pp. 1048.
8. Larson, R. A. 1980. *Introduction to Floriculture*. New York Academic Press. pp. 628.
9. Laurie, A. & Rees V.H. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publications, Jodhpur. pp.534.
10. Prasad, S. & Kumar, U. 2003. *Commercial Floriculture*. Agrobios Publications, Jodhpur.
11. Randhawa, G.S. & Mukhopadhyay, A. 2001. *Floriculture in India*. Allied Publ. pp 660.
12. Reddy S, Janakiram T, Balaji, Kulkarni S. &Misra RL. 2007. *Hi-Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi, India.
13. Singh, A. K. 2006. *Flower Crops: Cultivation and Management*. NIPA, New Delhi, pp. 475.


## FLS 525 INDOOR PLANTS AND INTERIORSCAPING 2(1+1)

**WHY THIS COURSE?**

Indoor plants are an important component of floriculture. They not only improve the aesthetic environment of indoors but are also known to improve indoor air quality. The students in floriculture need up to date knowledge on factors affecting indoor growing, types, cultural operations and different principles of **interiorscaping**.

**AIM OF THIS COURSE**

To facilitate deeper understanding of the benefits of indoor plants, selection, designing and their management. The course is organized as follows

| S.No. | Blocks | 1. Units |
|---|---|---|
| 1. | Scope, principles and operations | 2. Importance and scope |
| | | 3. Classification and principles |
| | | 4. Cultural operations |
| 2. | Presentations and marketing | 1. Special gardens |
| | | 2. Vertical gardens |
| | | 3. Marketing |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to develop

1. Deep understanding and knowledge of principles affecting indoor cultivation including vertical gardens
2. Develop required skills in interiorscaping
3. Develop required entrepreneurial acumen.

**THEORY**

**Block 1: Scope, principles and operations**

**UNIT-I:** *Importance and scope*: Importance and scope of indoor plants and Interiorscaping, Indoor plants and Indoor air quality.

**UNIT-II:** *Classification and principles*: Factors affecting growth, development and flowering of Indoor plants. Classification of indoor plants based on light, temperature, humidity and pollution tolerance, Description and cultivation of various indoor plants. Principles of Interiorscaping, Role in pollution mitigation

**UNIT-III:** *Cultural operations*: Containers and substrates, preparation of growing media, propagation, training, grooming, nutrition, management of disease, pests and weeds. Maintenance of plants including repotting, foliar nutrition, light exposure and plant rotation. Media standards, Nursery and Export standards for potted plants, Nursery standards.

**Block 2: Presentations and marketing**

**UNIT-I:** *Special gardens*: Special gardens including miniature gardens and plant stand. Presentations like dish, terrarium, bottle gardens, hanging baskets, window boxes and Bonsai.

**UNIT-II:** *Vertical gardens*: Vertical gardens- History, planting material, structures, containers, substrate, water and nutrient management, supplemental lighting.

**UNIT-III:** *Marketing:* Marketing channels, Business models including plant rentals.

**PRACTICAL (16)**

1. Identification of important house plants (2)
2. Media and containers (1)
3. Propagation (1)
4. Cultural operations, maintenance and economics of indoor plants (2)
5. Models for Interiorscaping (2)
6. Familiarization with different indoor gardens (2)
7. Making of terrariums, bottle garden, dish garden and their economics (2).
8. Making of vertical gardens and economics (2)
9. Exposure visits (2)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**


1. Barbara, P. (2005). *The Complete Houseplant Survival Manual*. Storey Publ., New Adams.
2. Randhawa, G.S. & Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publ.
3. Wallach, C. (1995). *Interior Decorating with Plants*. McMillan Seed Prod. Co. Inc., New York.


## FLS 526 SEED PRODUCTION IN FLOWER CROPS 2(1+1)

**WHY THIS COURSE**

Seed production of flowers is a highly remunerative enterprise. The students need to have knowledge of seed industry, seed production methods and seed certification. This course provides hands on training on seed production of important flower crops.

**AIM OF THIS COURSE**

To impart basic knowledge about the importance of seed production in important flower crops.
The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Seed Industry | 1. Scenario of Seed industry |
| 2. | Hybrid Seed Production | 1. Seed Production methods |
| | | 2. Population improvement |
| | | 3. $F_1$ Hybrid production |
| 3. | Regulations | 1. Seed certification and standards |

**COURSE OUTCOMES**

After successful completion of this course,

1. The students will get a thorough knowledge on seed industry, principles and methods of seed production in flower crops.
2. Students will get awareness on seed standards, certification and law in flower crops.

**THEORY**

**Block 1**

**UNIT-I:** *Scenario of Seed Industry*: Scope, scenario and importance of seed production in flower crops. Constraints in flower seed production. Marketing and economics of flower seeds.

**Block 2**

**UNIT-I:** *Seed production Methods*: Methods of seed production, agro techniques for production of nucleus, breeder and certified seeds. Harvesting, seed processing, seed priming, seed chain, packaging and storage.

**UNIT-II:** *Population improvement*: Mass selection, progeny selection. Use of incompatibility and male sterility, maintenance of variety and seed production in flower crops.

**UNIT-III:** *$F_1$ hybrids*: $F_1$ hybrid seed production advantages, steps involved in hybrid seed production, pollination behaviour and isolation, pollination management methods in production of $F_1$/ hybrids in different flower crops

**Block 3: Regulations**

**UNIT-I:** *Seed certification and stand*ards: Seed certification, Seed standards, seed act, plant breeders rights and farmers' rights, Bio safety, handling of transgenic seed crops, importing of seeds and OGL, trade barriers in seed business, sanitary and phytosanitary issues, custom clearance and quarantine.

**Crops:** Marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum, poppy, corn flower, rice flower,

**PRACTICAL (16)**

1. Seed production of open pollinated varieties (2)
2. Seed production of cross pollinated varieties (2)
3. Steps involved in hybrid seed production (2)
4. Hybrid seed production in different flower crops like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum *etc*. (6)
5. Visit to seed industry (3)
6. Visit to quarantine facility (1)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**


1. Bhattacharjee, S.K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
2. Bose, T.K., Yadav, L.P., Pal, P., Parthasarathy, V.A. & Das, P. 2003. *Commercial Flowers*. Vol. I & II. Naya Udyog, Kolkata.
3. Davies, Fred T. Jr., Geneve R. L., Wilson S. B., Hartmann, H. T., Kester, D. L. 2018. *Hartmann and Kester's Plant Propagation: Principles and Practices*. Pearson Publ. 9th Ed.
4. Larson, R.A. & Armitage A. M. 1992. *Introduction of Floriculture*. IBDC, Lucknow.


## FLS 531 VALUE ADDITION IN FLORICULTURE 3(2+1)

**WHY THIS COURSE?**

Value addition is done to increase the economic value of any floriculture commodity. Students need to develop thorough understanding of scope, scenario and different methods of value addition so that they can improve the income of the stakeholders by value addition.

**AIM OF THIS COURSE**

To understand the avenues for value addition in floriculture

The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Value added products | 1. Scope and scenario |
| | | 2. Value addition of loose flowers |
| | | 3. Floral Arrangements |

| | | |
|---|---|---|
| | | 4. Dry flowers |
| 2. | Extraction of value added products | 1. Essential oils |
| | | 2. Pigments and nutraceuticals |
| | | 3. Drying |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to
1. Understand and prepare different value added products from flowers
2. Develop entrepreneurial acumen
3. Imbibe the skills for making various value added products

**THEORY**

**Block 1: Value added products**

**UNIT-I:** *Scope and scenario*: Scope and prospects of value addition, National and global scenario, production and exports. Types of value added products, techniques of value addition including tinting.

**UNIT-II:** *Value addition in loose flowers*: Value addition in loose flowers and product development-Gulkhand, floral tea, rose oil, rose water, Pankhuri, floral dyes, rose sherbet, floral ice creams, sweets, *etc*.

**UNIT-III:** *Floral Arrangements*: Selection of containers and accessories for floral products and decorations. Flower arrangement, styles, ikebana schools (ikenobo, ohara, sogetsu *etc*.), Ikebana-moribana, nagiere, contemporary style.

**UNIT-IV:** *Dry flowers*: Dry flowers– Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; tips for collecting dry flower making, selection of stages for picking of flowers for drying, Techniques in dry flower making – Drying, glycerising, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; petal embedded handmade papers, Packaging and storage. Post drying management including moisture, pests and molds.

**Block 2: Extraction of value added products**

**UNIT-I:** *Essential oils*: Essential oils; Selection of species and varieties (including nonconventional species), extraction methods, Packing and storage, Aromatherapy.

**UNIT-II:** *Pigments and nutraceuticals*: Types of pigments, carotenoids, anthocyanins, chlorophyll, betalains; Significance of natural pigments as nutraceuticals, Extraction methods and applications in food, pharmaceutical and poultry industries.

**UNIT-III:** *Dying*: Synthetic and Natural dyes, dying techniques, colour retention,

**PRACTICAL (16)**

1. Practices in preparation of different type of flower arrangements including bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers (4)
2. Techniques in flower arrangement and floral decoration (2)
3. Identification of plants for dry flower making (2)
4. Practices in dry flower making; Preparation of dry flower baskets, bouquets, potpourri, wall hangings, button holes, greeting cards, wreaths, *etc*. (2)
5. Essential oil extraction units (1)
6. Extraction of pigments (2)
7. Visit to dry flower units (2)
8. Economics of value added products (1)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**


1. Bhattacharjee, S.K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
2. Chadha, K.L. & Bhattacharjee, S.K. 1995. *Advances in Horticulture: Ornamental Plants*. Vol. XII, Parts 1 & 2. pp.533 & pp.574. Malhotra Publ. House, New Delhi.
3. Lauria, A. & Victor, H.R. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur.
4. Nowak, J. & Rudnicki, R.M. 1990. *Postharvest handling and storage of cut flowers, florist greens, and potted plants*. Timber Press, USA. pp. 210.
5. Prasad, S. & Kumar, U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur.
6. Reddy, S., Janakiram, T., Balaji T., Kulkarni, S. &Misra, R.L. 2007. *Hi- Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi.


## FLS 532 TURF GRASS MANAGEMENT 3(2+1)

**WHY THIS COURSE?**

Turf grass management deals with establishment and maintenance of different turf grasses for aesthetic, recreational and sports purposes. The course deals with basic types, requirement of turf grasses, management and development of turf for different purposes.

**AIM OF THIS COURSE**

To understand the science, principles and management of turf grasses.
The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Turf Industry and turf management | 1. Prospects and basic requirement |
| | | 2. Types of turf grasses |
| | | 3. Operations and management |
| 2. | Turf for different grounds | 1. Making of different sports arenas |
| | | 2. Automation in turf management |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to
1. Deep understanding and knowledge of different types of grasses and their management
2. Developing skills for turfing of different arenas
3. Develop required entrepreneurial acumen

**THEORY**

**Block 1: Turf industry and turf management**

**UNIT-I:** *Prospects and basic requirement*: History, present status and prospects of turf industry; basic requirements, site selection and evaluation, concepts of quality of soil pertaining to turf grass establishment, criteria for evaluation of turf quality.

**UNIT-II:** *Types of turf grasses*: Types, species, varieties, important breeders, grasses for different locations and conditions and their compatible groupings as per climatic conditions; Turfing for roof gardens.

**UNIT-III:** *Operations and management*: Preparatory operations; Turf establishment methods such as seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, instant turfing (portable), hydro-seeding, synthetic turfing. Turf management – Irrigation, drainage, nutrition, special practices like aerating, rolling, coring, dethatching, verticutting, soil top dressing, use of plant growth regulators and micronutrients, Turf mowing – mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs, standards for turf, use of recycled water *etc.*,

**Block 2: Turf for different grounds**

**UNIT-I:** *Making of different sports arenas*: Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, residential and public parks, turfing of Govt. & Corporate office gardens, event specific preparation, turf colourants.

**UNIT-II:** *Automation*: *in truft* management exposure to different tools, gadgets, machinery used in turf industry.

**PRACTICAL (16)**

1. Identification of turf grasses and turf machinery (1)
2. Soil preparation, turf establishment methods, provision of drainage (2)
3. Layout of macro and micro irrigation systems (1)
4. Water and nutrient management (2)
5. Special practices – mowing, raking, rolling, soil top dressing, weed management (2)
6. Biotic and abiotic stress management (2)
7. Project preparation for turf establishment (2)
8. Visit to parks, model cricket grounds & golf courses, airports, corporates, Govt. organizations (2)
9. Rejuvenation of lawns (1)
10. Turf economics (1)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**

1. Aldous, D.1999. *International Turf Management Handbook*. CRC Press. pp.368.
2. Beard, J.B. 1972. *Turf Grass Science and Culture*. Pearson. 1st edition, pp. 672.
3. Chawla, S.L., Patil, S., Patel, M.A., Patel, R.B. & Patel, R.M. 2013. *Turf grass Management.* Published by NAU, Navsari.
4. Emmons, R. 2007. *Turf grass Science and Management.* Cengage Learning Publ. 4th ed., pp.592.
5. Nick-Christians. 2011. *Fundamentals of Turf grass Management.* Wiley; 4th Ed., pp.424.
6. Turgeon, A.J.1980. *Turf grass Management.* Reston Publ. Inc.

## FLS 533 CAD FOR LANDSCAPING 3(1+2)

**WHY THIS COURSE?**

CAD is widely used in landscaping planning and design. The students need to develop in depth knowledge of CAD software so that they can modify raw data into plans, drawing and models for landscape planning.

**AIM OF THIS COURSE**

To impart basic knowledge about the Computer Aided Designing (CAD) of landscape.
The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | CAD | 1. CAD basics and applications |
| | | 2. 2D drawing |
| 2. | ARCHICAD | 1. 3D drawing |
| | | 2. Dimensioning and visualization |

**LEARNING OUTCOMES**

After successful completion of this course, the students are expected to develop

1. The students will be able to use CAD and ARCHICAD for landscape planning and designing.
2. Develop the adequate skills to create 3 D model to showcase interaction of different factors in landscape gardening.
3. Develop the entrepreneurial acumen.

**THEORY**

**Block 1: CAD**

**UNIT-I:** *CAD basics and applications*: Principles of integrating the architecture and landscaping, Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing.

**UNIT-II:** *2D drawing:* 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects. Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking, Script making, Using productivity tools, e-transmit file, making sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout.

**Block 2: ARCHICAD**

**UNIT-I:** *3D drawing*: 3D drawing methods, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD.

**UNIT-II:** *Dimensioning and visualization*: ARCHICAD organization tools, Dimensioning and detailing of designs, Landscape designing softwares and CD ROM for ornamental plant material (TRES, HIMFLORA, CAPSSA, *etc*), Attribute settings of components, Visualization tools for landscape preview, Data management, plotting and accessories for designing, Inserting picture using photoshop, Making sample drawing for outdoor and indoor gardens.

**PRACTICAL (30)**

1. Practices in point picking methods, Using tool bars and icons, Using modifying tools and modifying comments (4).
2. Isometric drawings, Using productivity tools (2).
3. Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden (4).
4. Using tools and info-box for 3D drawing, Creation of garden components with ARCHICAD (4).
5. Organization, dimensioning, detailing and visualization tools with ARCHICAD (4)
6. Using Photoshop package for 3D picture insertion (2)
7. Drawing designs with ARCHICAD for home garden, interior garden designing, IT parks, Corporates, Theme parks and Ecotourism spots (6).
8. Exposure visits (4)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits.

**SUGGESTED READINGS**

1. Christine, Wein-Ping Yu. 1987. *Computer-aided Design: Application to Conceptual Thinking in Landscape Architecture*. amazon.com.
2. Misra, R.L. & Misra, S. 2012. *Landscape Gardening*. Westville Publ. House, New Delhi.

# COURSE CONTENTS: Ph.D. FLORICULTURE AND LANDSCAPING

## FLS 611 CROP REGULATION IN ORNAMENTAL CROPS 3(2+1)

**WHY THIS COURSE?**

The course deals with the physiological and biochemical basis of crop regulation and programmed production of flower crops. The students need a thorough understanding on crop regulation to improve the profitability of growers.

**AIM OF THIS COURSE**

Appraise on advances in programmed production of flower crops

The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Basis of crop regulation | 1. Basis of flowering |
| | | 2. Growth regulators |
| 2. | Programming | 1. Growth regulation |
| | | 2. Programmed production |

**COURSE OUTCOMES**

After successful completion of this course,

1. The students will be abreast with physiological and biochemical basis of crop regulation in flower crops.
2. The students will be able to carry out programmed production of flower crops.
3. Instil the entrepreneurial acumen in the students

**THEORY**

**Block 1: Basis of crop regulation**

**UNIT-I:** *Basis of flowering:* Ecophysiological influences on growth and development of flower crops for flowering, Crop load and assimilate partitioning and distribution. Root and canopy regulation,

**UNIT-II:** *Growth regulators:* Study of plant growth regulators including bio stimulants and polyamines in floriculture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants. Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, Plant architecture management for flower crops and ornamental plants, molecular approaches in crop growth regulation.

**Block 2: Programming**

**UNIT-I:** *Growth regulation:* Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, flower bud initiation, regulation of flowering, photo and thermo periodism, off season production, bulb forcing techniques,

**UNIT-II:** *Programmed production*: Programmed production of important flower crops like chrysanthemum, tulips, lilium, daffodils, poinsettia, kalanchoe, gypsophila.

**PRACTICAL**

1. Plant architecture studies in important flower crops (2)
2. Bioassay and isolation through chromatographic analysis for auxins, gibberellins, cytokinins, ABA (4)
3. Growth regulation during propagation, dormancy, flowering (2)
4. Photoperiod regulation in short day and long day crops (2)
5. Off season production in important crops (2)
6. Bulb forcing in bulbous ornamental crops (2)
7. Exposure visits (2)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes

- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**


1. Buchanan, B. Gruiessam, W. & Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*. 2015. Wiley Blackwell Publ. 2nd Edition, pp. 1280.
2. De Hertagh, A. & Le Nard, M. 1993. *The Physiology of Flower Bulbs*. Elsevier, London, UK.
3. Epstein, E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives.* John Wiley & Sons.
4. Fosket, D.E. 1994. *Plant Growth and Development: A Molecular Approach*. Acad. Press. Pp. 580.
5. Leoplod, A.C. & Kriedermann, P.E. 1985. *Plant Growth and Development*. McGraw-Hill, NY. 3rd Ed
6. Peter, K.V. 2008. *Basics of Horticulture*. New India Publ. Agency, New Delhi.
7. Roberts, J., Downs, S. & Parker, P. 2002. *Plant Growth Development: In* Plant. Oxford University Press. pp. 221-274.
8. Salisbury, F. B. & Ross, C.W. 1992. *Plant Physiology, Hormones and Plant Regulators: Auxins and Gibberellins*. Wadsworth Publ., Belmont. 4th Edition, pp. 357-381.


## FLS 612 POSTHARVEST BIOLOGY OF FLORICULTURAL CROPS 3(2+1)

**WHY THIS COURSE?**

The course deals with physiological, biochemical basis of senescence of flowers and the treatments and packaging methods to mitigate these processes for improving post-harvest life.

**AIM OF THIS COURSE**

To facilitate deeper understanding of biochemistry and postharvest technology in flowers at molecular as well as applied level.

The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Pre-harvest and post-harvest physiology and biochemistry | 1. Pre harvest physiology |
| | | 2. Senescence |
| | | 3. Pigments and secondary metabolites |
| 2. | Storage and packaging | 1. Treatments and storage |
| | | 2. Packaging |
| | | 3. Recent trends |
| | | 4. Dried ornamental crops |

**COURSE OUTCOMES**

After successful completion of this course,

1. The students will be abreast with physiological and biochemical basis of senescence in flower crops.
2. The students would acquire the required skill sets of managing the storage and packaging methods to be followed in case of flowers.
3. Prepare the students to explore the entrepreneurial options in post-harvest management.

**THEORY**

**Block 1: Preharvest and post-harvest physiology and biochemistry**

**UNIT-I:** *Pre harvest physiology*: Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and other biochemical changes, respiration, transpiration in important flower crops.

**UNIT-II:** *Senescence*: Physiology and biochemistry of flowering, enzymatic changes, Ethylene sensitivity, ethylene evolution and management, factors leading to post-harvest loss, pre-cooling. Petal senescence at molecular level, functional gene analysis for postharvest flower quality in important flower crops *etc*.

**UNIT-III:** *Pigments and secondary metabolites*: Biosynthetic pathways of chlorophyll, xanthophyll, carotenoids, flavonoids and anthocyanins and betalains. Chemistry and importance of secondary metabolites. Biochemistry and utilization for commercial products in important flower crops.

**Block 2: Storage and packaging**

**UNIT-I:** *Treatments and Storage of flowers*: Treatments prior to shipment, viz., precooling, pulsing, impregnation, chemicals, Irradiation, biocontrol agents and natural plant products. Methods of storage: ventilated, refrigerated, Modified atmosphere, Controlled atmosphere storage, cool chain management, physical injuries and disorders in important flower crops.

**UNIT-II:** *Packaging*: Packing methods and transport, Smart technologies in packaging and storage, advanced tools like nanotechnology application for quality parameters and post-harvest treatments for export in important flower crops, packaging standards, flower labels value chain in floriculture,

**UNIT-III:** *Recent trends*: Recent trends- extraction of bio-colours from flowers-conventional as well as in vitro methods and their value addition uses in food and textile industries. Molecular techniques for enhancing postharvest flower quality, transgenics in ornamental plants for enhanced postharvest life.

**UNIT-IV:** *Dried ornamental crops*: Post harvest handling of dried ornamental crops including packing, storage and shipment. Storage pest and mould problems in dried ornamental produce, colour retention, physiological and biochemical changes, *etc*.

**PRACTICAL**

1. Improved packaging and storage of important flowers (2).
2. Physiological loss in weight of flowers, estimation of transpiration, respiration rate, ethylene release and study of vase life (2)
3. Extension in cut flower vase life using chemicals (1)
4. Estimation of quality characteristics in stored flowers (1).
5. Estimation of biochemical changes like enzymatic changes, lipids and electrolyte leakage (2)
6. Extraction of flower pigments – Chlorophyll, xanthophylls, carotenoids and anthocyanins (4)
7. Cold chain management - visit to cold storage, MA and CA storage units (2)
8. Project preparation (2)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**

1. Buchanan, B. Gruiessam, W. & Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*. 2015. Wiley Blackwell Publ. 2nd edition, pp. 1280.
2. Dey, P.M. & Harborne, J.B. 1997. *Plant Biochemistry*. Academic Press. 2nd Edition.
3. Glover, M.D. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall Publ.
4. Goodwin, T.W. & Mercer, E.I. 2003. *Introduction to Plant Biochemistry*. CBS Publ.

## FLS 621 ADVANCES IN PRODUCTION TECHNOLOGY OF FLOWER CROPS 3(2+1)

**WHY THIS COURSE?**

Production technology of flower crops is undergoing a rapid change due to advances from other sciences. The students need to keep abreast with these advances in production technology in flower crops.

**AIM OF THIS COURSE**

To keep abreast with latest developments and trends in production technology of flower crops.
The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Production technology | 1. Scope and scenario |
| | | 2. Cultural operations |
| | | 3. Crop regulation |
| | | 4. Advances in production technology of flowers |
| 2. | Mechanization and Post-harvest management | 1. Mechanization |
| | | 2. Post-harvest management |

**COURSE OUTCOMES**

After successful completion of this course,

1. The students will acquire knowledge and skills in advances in production technology, crop regulation and mechanization in flower crops.
2. Develop enterprising attitude among students.

**THEORY**

**Block 1: Production technology**

**UNIT-I:** *Scope and scenario*: Commercial flower production; Scope and importance; Global Scenario in cut flower production and trade, varietal wealth and diversity; Soil and Environment; cut flower, loose flowers, dry flowers and essential oil trade, flower seed production. Special characteristics and requirements. Essential oil industry, recent advances in extraction methods.

**UNIT-II:** *Cultural operations*: Propagation and multiplication; Greenhouse management; Soil/media decontamination techniques; Micro-irrigation; nutrition and fertigation; slow release fertilizers and biofertilizers; influence of environmental parameters, light, temperature, moisture, humidity and CO2on growth and flowering.

**UNIT-III:** *Crop Regulation*: Flower forcing and year-round flowering through physiological interventions; Chemical regulation; Environmental manipulation, important insect pests, diseases, nematodes and their management through IPM and IDM, quarantine measures for export and other export norms.

**UNIT-IV:** *Advances in production technology of flower crops*: Advances in roses, chrysanthemum, carnation, tuberose, gladiolus, lilum, gerbera, orchids, anthuriums, *etc*.

**Block 2: Mechanization and Post-harvest management**

**UNIT-I:** *Mechanization*: Mechanization, automation, ICT and AI in floriculture.

**UNIT-II:** *Post harvest management*: Harvest indices, Harvesting techniques; Post harvest handling for local, distant and export market, Cluster production, Contract farming, FPOs, Value chain management.

**PRACTICAL (16)**

1. Greenhouse management; Soil decontamination techniques (2)
2. Micro-irrigation; Nutrition and fertigation (2)
3. Special practices- bending, netting, pinching, disbudding, defoliation and chemical pruning *etc.* (2)
4. Photoperiodic and chemical induction of flowering (2)
5. Assessing harvest indices; Post-harvest handling (2)
6. Case studies (2)
7. Visit to commercial cut flower and essential oil units (4)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**

1. Bose, T.K., Maiti, R.G., Dhua, R.S. & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata.

2. Chadha, K. L. & Choudhury, B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi.
3. George, S. & Peter, K.V. 2008. *Plants in a Garden*. NIPA, New Delhi.
4. Lauria, A. & Victor, H.R. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur.
5. Misra, R.L. & Misra, S. 2017. *Commercial Ornamental Crops: Traditional and Loose Flowers*. Kruger Brentt Publisher UK Ltd.
6. Randhawa, G.S. & Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publ.
7. Reddy, S., Janakiram, T., Balaji T., Kulkarni, S. & Misra, R.L. 2007. *Hi-Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi.
8. Singh, A.K. 2006. *Flower Crops: Cultivation and Management*. NIPA, New Delhi.
9. Singh, A.K. 2014. *Breeding and Biotechnology of Flowers, Vol.1: Commercial Flowers*. NIPA, New Delhi. pp.740.

## FLS 622 ADVANCES IN LANDSCAPE GARDENING 3(1+2)

**WHY THIS COURSE?**

Advances in landscape gardening is a course which deals with principles of landscape design, landscape engineering and site analysis. It will also create awareness on latest developments in landscape gardening among students.

**AIM OF THIS COURSE**

To update knowledge on the recent trends in the field of landscape designing and developing practical skills.

The course is organized as follows:

| S.No. | Units |
|---|---|
| 1. | Landscape design |
| 2. | Site analysis |
| 3. | Software in landscaping |
| 4. | Landscaping for different situations |
| 5. | Maintenance |

**COURSE OUTCOMES**

After successful completion of this course,

1. The students will be abreast with the recent advances in landscape gardening
2. Acquire the skills to independently handle landscape projects

**THEORY**

**UNIT-I:** *Landscape design:* Commercial landscape gardening- History, Plant identification and ecology, Materials of garden design, Design making by different garden styles and types. Design principles in ancient and modern landscape. Principles of designing a commercial landscape project. Role of landscaping in environment improvement, ecology conservation (birds, butterflies, animals). Plant wealth for edges, hedges, herbaceous borders, trees, floral beds, water plants, cacti, ferns, palms *etc*.

**UNIT-II:** *Site analysis:* Assessing site and plants adaptability for different locations, Landscape engineering (Topographical survey and designing concept including GIS, GPS, Remote sensing), special techniques in garden landscaping (Burlapping, waterscaping, xeriscaping, hardscaping, lawn establishment, topiary styles specializing, bioaesthetic planning).

**UNIT-III:** *Software in landscaping:* Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing.

**UNIT-IV:** *Landscaping for different situations:* Contemporary landscaping, Urban landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, playground landscaping, Inventory management, Landscape restoration, Assessing a successful design in site.

**UNIT-V:** *Maintenance:* Maintenance of different types of gardens, waste water utilisation, historical and archaeological garden sites, Permissions required for bigger projects, carbon sequestration, carbon credits *etc.*,

**PRACTICAL (32)**

1. Plant identification (1)
2. Materials of garden design, Design making by different garden styles and types (2)
3. Assessing site and plants adaptability for different locations (2)
4. Way of designing a commercial landscape project (4)
5. Landscape engineering (Topographical survey and designing concept) (2)
6. Preparation and drawing of site plan (4)
7. Learning the basics in computer aided design (CAD) for developing a garden landscape plan (4)
8. Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing (4)
9. Case study with the successful landscapist (4)
10. Budget/Project cost estimating (2)
11. Exposure visits (3)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**

1. Bose, T.K., Maiti, R.G., Dhua, R.S. & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata.
2. Nambisan, K.M.P.1992. *Design Elements of Landscape Gardening*. Oxford & IBH Publ. Co., New Delhi.
3. Ozayuvuz, M. 2013. *Advances in Landscape Architecture*. In Tech Open Publ.
4. Woodrow, M.G. 1999. *Gardening in India*. Biotech Books, New Delhi.

## FLS 623 SPECIALTY FLOWERS, FILLERS AND CUT GREENS 2(1+1)

**WHY THIS COURSE?**

This course deals with introduction to specialty flowers, cut greens and fillers, ways to cultivate them and their post-harvest handling and storage. The students need to be aware of these crops so that they could improve the profitability of growers.

**AIM OF THIS COURSE**

To impart the knowledge on importance and cultivation of specialty flowers, fillers and cut green crops.

The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Scope | 1. Importance, national and international scenario |
| 2. | Avenues | 1. Specialty flowers |
| | | 2. Fillers |
| | | 3. Cut greens |
| 3. | Trade and marketing | 1. Post-harvest management and marketing |
| | | 2. Standards |

**COURSE OUTCOMES**

After successful completion of this course,

1. The students will gain knowledge on different specialty flowers, cut greens, fillers their cultivation practices and post-harvest management.
2. Infuse confidence to take up cultivation as an enterprise.

**THEORY**

**Block 1: Scope**

**UNIT-I:** *Importance, national and international scenario*: Introduction, present status, scope, importance and avenues for specialty flowers and cut greens.

**Block 2: Avenues**

**UNIT-I:** *Specialty flowers*: Cultivation practices of specialty flower crops like heliconia, red ginger, Bird of Paradise, Ornamental banana, ornamental curcuma, gingers, wax flower, kangaroo paw, limonium, rice flower, *etc*.

**UNIT-II:** *Fillers:* Cultivation practices of fillers like gypsophila, solidago, Mollucella, lupins *etc*.

**UNIT-III:** *Cut greens*: Cultivation practices of cut greens like anthurium, ferns, asparagus, cycas, thuja, bottle brush, ornamental palms, zanado, dracaena, eucalyptus, ruscus, dianella, alpinia, *etc*.

**Block 3: Trade and Marketing**

**UNIT-I:** *Post harvest management and marketing*: Pre and post-harvest factors influencing the vase life of the flowers and fillers, Post-harvest management including pulsing, holding, packing, storing, forward and backward linkages, value chain management

**UNIT-II:** *Standards*: Quality standards, Packaging standards, marketing and trade in important flower, filler and foliage crops.

**PRACTICAL (16)**

1. Identification of specialty flowers, fillers and cut greens (2)
2. Media and bed preparation for cultivation (2)
3. Propagation of important crops (2)
4. Integrated disease and pest management in important crops (2)
5. Post-harvest handling of specialty flowers, fillers and cut greens (2)
6. Preparation of value added products from important specialty flowers, fillers and foliages (2)
7. Exposure visits (2)
8. Economics and Project preparation (2)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**


1. Armitage, A.M. & Laushman, J.M. 2008. *Speciality Cut Flowers*. Timber Press. 2nd Ed. pp.636.
2. Bhattacharjee, S.K. 2006. *Vistas in Floriculture*. Pointer Publ., Jaipur, India.
3. Bhattacharjee, S.K. & De, L.C. 2003. *Advanced Commercial Floriculture* Vol.1. Aavishkar Publ. & Distributors, Jaipur.
4. Bose, T.K., Yadav, L.P., Pal, P., Parthasarathy, V.A. & Das, P. 2003. *Commercial Flowers*. Vol. I & II. Naya Udyog, Kolkata, India.
5. Misra, R.L. & Misra, S. 2017. *Commercial Ornamental Crops: Traditional and Loose Flowers*. Kruger Brentt Publisher UK Ltd.
6. Mukherjee, D. 2008. *Speciality Cut Flowers-Production Technologies*. Naya Ud. Kolkata, pp. 614.
7. Salunkhe, K., Bhatt, N.R. & Desai, B.B. 2004. *Post-harvest Biotechnology of Flowers and Ornamental Plants*. Naya Prokash, Kolkata, India.


## FLS 624 BIOTECHNOLOGICAL APPROACHES IN FLORICULTURAL CROPS 3(2+1)

**WHY THIS COURSE?**

This course deals with advances in biotechnology of flower crops. The student needs to be abreast with recent advances in tissue culture, genetic engineering and molecular biology of flower crops.

**AIM OF THIS COURSE**

Equip the students with the advances in application of biotechnology in flower crops.

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Scope of biotechnology | 1. Scope of biotechnology |
| 2. | Cell, Tissue and Organ culture | 1. Tissue cultures |
| | | 2. Somaclonal variation and in vitro conservation |
| 3. | Genetic engineering and molecular biology | 1. Genetic Engineering |
| | | 2. Molecular approaches |

**THEORY**

**Block 1: Scope of biotechnology**

**UNIT-I: *Scope of biotechnology*:** Present status of biotechnology, tools techniques and role in floriculture industry, physical factors and chemical factors influencing the growth and development of plant cell, tissue and organs, cyto-differentiation, organogenesis, somatic embryogenesis in important flower crops.

**Block 2: Cell, tissue and organ culture**

**UNIT-I: *Micropropagation*:** In vitro lines for biotic and abiotic stress – Meristem culture for disease elimination, production of haploids through anther and pollen culture – embryo and ovule culture, micrografting, wide hybridization and embryo rescue techniques, construction of somatic hybrids and cybrids, regeneration and characterization of hybrids and cybrids, in vitro pollination and fertilization, hardening media, techniques and establishment of tissue culture plants in the primary and secondary nursery in important flower crops.

**UNIT-II: *Somaclonal variation and in vitro conservation*:** Somoclonal variation and its applications – variability induction through in vitro mutation, development of cell suspension cultures, types and techniques, Synthetic Seed technology, in vitro production of secondary metabolites, role of bioreactors in production of secondary metabolites, quantification and quality analysis of secondary metabolites using HPLC/ MS/GCMS/ in vitro conservation and cryo-preservation techniques in important flower crops.

**Block 3: Genetic engineering and molecular biology**

**UNIT-I: *Genetic engineering*:** Gene cloning, genetic engineering: vectors and methods of transformation – electroporation, particle bombardment, Functional gene analysis techniques like PTGS including VIGS in ornamental plants, Agrobacterium mediated, transgenic plants in flower crops, Biosafety of transgenics isolation of DNA, RNA, quantification, Polymerase Chain Reaction for amplification; AGE & PAGE techniques; identification of molecular markers in important flower crops.

**UNIT-II: *Molecular approaches*:** Molecular markers as a tool for analysis of genetic relatedness and selection in ornamental crops. Molecular control of flower development, light sensing with respect to plant development, flower pigmentation, fragrance, senescence, ethylene synthesis pathway in important flower crops. Molecular biology- Gene isolation, characterization, manipulation and transfer in important flower crops. Construction of c- DNA library, DNA fingerprinting technique in economic flower crop varieties, RNAi, Genome editing basics, molecular approaches to control ethylene response, Fragrance, Plant Architecture, desirable flower traits, colour, shape, improving postharvest life, improving resistance for environmental stress, approaches to improve flower development, pigment production, secondary metabolite production, post-harvest biotechnology of flowers, ornamental plants, achievements of bio-technology in flower crops.

**PRACTICAL**

1. Micropropagation, Pollen- Ovule and Embryo culture- Synthetic seed production (2)
2. In vitro mutation induction, in vitro rooting – hardening at primary and secondary nurseries (3).
3. DNA isolation from economic flower crop varieties – Quantification and amplification (2)
4. DNA and Protein profiling – molecular markers, PCR Handling (2)
5. Vectors for cloning and particle bombardment (3)
6. DNA fingerprinting of flower crop varieties (3)
7. Project preparation for establishment of low, medium and high cost tissue culture Labs. (1)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**


1. Chopra, V.L. & Nasim, A. 1990. *Genetic Engineering and Biotechnology-Concepts, Methods and Applications*. Oxford & IBH Publ. Company, USA. pp. 200.
2. Debnath, M. 2011. *Tools and Techniques of Biotechnology*. Pointer Publ.
3. Glover, M.D. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall Publ.
4. Gorden, H. & Rubsell, S. 1960. *Hormones and Cell Culture*. AB Book Publ.
5. Keshavachandran, R., Nazeem, P. A., Girija, D., John, P.S. & Peter, K.V. 2007. *Recent Trends in Horticultural Biotechnology*. Vols. I & II, 1018 p. NIPA, New Delhi.
6. Keshavachandran, R. & Peter, K.V. 2008. *Plant Biotechnology: Methods in Tissue Culture and Gene Transfer*. Orient Blackswan. 312 p.


## FLS 625 VERTICAL GARDENING 3(1+2)

**WHY THIS COURSE?**

This course deals with development in vertical gardening which is expanding across the country. In view of the unprecedented pollution, advent of smart cities demand for green walls/living walls is increasing day by day. The students therefore need to be equipped with the advancements taking place to offer solutions.

**AIM OF THIS COURSE**

Equip the students with the latest developments in vertical gardening.

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Importance | 1. Scope |
| | | 2. Growth |
| | | 3. Making of vertical garden |
| 2. | Green roofing | 1. Green facades |
| | | 2. Mitigation of pollution |
| | | 3. Maintenance |

**THEORY**

**Block 1: Importance**

**UNIT-I:** *Scope:* Present status of vertical gardening, benefits of vertical gardening, History of vertical gardens, role of indoor plants in mitigating pollution.

**UNIT-II:** *Growth:* Factors influencing the growth and development of the plants including light, humidity, temperature, nutrition, irrigation, growth regulation.

**UNIT-III:** *Making of vertical gardens*: Containers, media, frames, cost effective components, cables, wires, nets for the vertical formations, modular living walls,

**Block 2: Green roofing**

**UNIT-I:** *Green Facades:* Influence of green facades in providing thermal comfort, atmospheric cleansing and related environmental benefits, Energy saving potential of green façades, Aesthetic appeal of green structures and other relevant studies on urban greening

**UNIT-II:** *Mitigation of pollution:* Plants suitable, Dust mitigation, Radiation absorption, Pollution mitigation, Acoustic attributes of urban greening

**UNIT-III:** *Maintenance:* Lifecycle, maintenance, Plants with low light, medium, high intensity requirement, cost effectiveness and overall sustainability of living walls

**PRACTICAL**

1. Identification of plants (2)
2. Components of vertical gardens (2)

3. Designing of vertical gardens for different locations (4)
4. Maintenance of vertical gardens (2)
5. Economics (1)
6. Project preparation (1)
7. Exposure visit (4)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**

1. Chopra, V.L. & Nasim, A. 1990. *Genetic Engineering and Biotechnology-Concepts, Methods and Applications.* Oxford & IBH Publ. Company, USA. pp. 200.
2. Debnath, M. 2011. *Tools and Techniques of Biotechnology*. Pointer Publ.
3. Glover, M.D. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall Publ.
4. Gorden, H. & Rubsell, S. 1960. *Hormones and Cell Culture*. AB Book Publ.
5. Keshavachandran, R., Nazeem, P. A., Girija, D., John, P.S. & Peter, K.V. 2007. *Recent Trends in Horticultural Biotechnology*. Vols. I & II, pp. 1018. NIPA, New Delhi.
6. Keshavachandran, R. & Peter, K.V. 2008. *Plant Biotechnology: Methods in Tissue Culture and Gene Transfer*. Orient Blackswan. pp. 312.

## FLS 626 ADVANCES IN BREEDING OF FLOWER CROPS 3(2+1)

**WHY THIS COURSE?**

There have been several advances in application of biotechnology of flower crops. The students need to be aware of a wide array of in vitro and molecular techniques with reference to flower crops.

**AIM OF THIS COURSE**

To teach students about the recent research trends in the field of breeding of ornamental crops with special emphasis on biotechnological approaches.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | *In vitro* techniques and biosynthetic pathways | 1. *In vitro* techniques |
| | | 2. Biosynthetic pathways |
| 2. | Molecular techniques | 1. Molecular breeding |
| | | 2. Genome editing |
| | | 3. Advances in flower crops |

**COURSE OUTCOMES**

After successful completion of this course,

1. The students will have in depth knowledge and hands on training in in vitro and molecular approaches that can be used in flower crops.
2. Equip the students with the skills for develop designer crops.

**THEORY**

**Block 1: In vitro techniques and biosynthetic pathways**

**UNIT-I:** *In vitro techniques*: Role of biotechnology in improvement of flower crops; in vitro mutagenesis, embryo culture, somaclonal variation, transformation, in vitro-cryopreservation, somatic hybridization, anther and ovule culture including somatic embryogenesis.

**UNIT-II:** *Biosynthetic pathways*: Biosynthetic pathways of pigment, fragrance and senescence, flower form; chemistry and importance of secondary metabolites, genomics, proteomics, metabolomics.

**Block 2: Molecular techniques**

**UNIT-I:** *Molecular breeding*: Molecular breeding and Marker assisted selection; molecular characterization; construction of c-DNA library; High throughput sequencing.

**UNIT-II:** *Genome editing*: Genome editing, CRISPER CAS, gene pyramiding, allele mining.

**UNIT-III:** *Advances in flower crops*: Breeding for biotic and abiotic stresses using biotechnological means; designer flower crops. Advancements in important flower crops like rose, chrysanthemum, carnation, orchids, anthuriums, lilium, gerbera *etc.*

**PRACTICAL (16)**

1. In vitro mutagenesis, embryo culture, somaclonal variation (2)
2. Somatic hybridization, anther and ovule culture and somatic embryogenesis (2)
3. Genetic transformation (2)
4. Genetic fingerprinting, Genome editing techniques (4)
5. PCR, genomics, blotting techniques (2)
6. Cloning, marker assisted selection (2)
7. Bioinformatics (2)

**TEACHING METHODS/ACTIVITIES**

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**


1. Anderson, N.O. 2007. *Flower Breeding and Genetics Issues, Challenges and Opportunities for the 21st Century*. Springer Publ., The Netherlands.
2. Arthur, M.L. 2013. *Introduction to Bioinformatics*. Oxford University Press, U.K. 400 p.
3. Chadha, K.L. & Chaudhury, B.1992. *Ornamental Horticulture in India*. ICAR, New Delhi.
4. Nelson, D.L. & Cox, M.M. 2000. *Principles of Biochemistry*. 4th Edition, Lehninger Publ.
5. Panopoulas, N.J. (Ed.). 1981. *Genetic Engineering in Plant Sciences*. Praeger Publ.
6. Parthasarathy, V.A., Bose, T.K., Deka, P.C., Das, P., Mitra, S.K. & Mohanadas, S. 2001. *Biotechnology of Horticultural Crops*. Vol. I-III. Naya Prokash, Kolkata, India.
7. Pierik, R.L.M. 1987. *In vitro Culture of Higher Plants*. Martinus Nijhoff Publ. Amsterdam.
8. Primrose, S.B. & Twyman, R. 2006. *Principles of Gene manipulation and Genomics*. Blackwell Publ., USA.
9. Vainstein, A. (Ed). 2002. *Breeding for Ornamental crops: Classical and Molecular Approaches*. Springer-Science-Business Media, B.V. 1st Edition.
10. Wilson, K. & Walker, J. 2010. *Principles and Techniques of Biochemistry and Molecular Biology*. 7th Edition, Cambridge University Press, UK.


## FLS 627 ADVANCES IN PROTECTED CULTIVATION OF FLOWER CROPS 3(2+1)

**WHY THIS COURSE?**

Protected cultivation is more rewarding in production of high value cut flowers. With appropriate structures and plant environment control measures, the constraints of environment prevalent in the region can be overcome allowing almost year-round cultivation. The students need to get updated with the recent advances in protected cultivation.

**AIM OF THIS COURSE**

Appraisal on the advances in protected and precision farming of flower crops.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Production technology | 1. Scope and Scenario |
| | | 2. Microclimate management |
| | | 3. Cultural operations |
| | | 4. Advances in flower crops |
| 2. | Precision floriculture and regulations | 1. Precision floriculture 2. Regulations |

**COURSE OUTCOMES**

After successful completion of this course,

1. The students will be abreast with the recent advances in protected cultivation of flower crops
2. Equip the students with skill to independently manage enterprises

**THEORY**

**Block 1: Production technology**

**UNIT-I:** ***Scope and Scenario****:* Prospects of protected floriculture in India, growing structures, basic considerations in establishment and operation of green houses, functioning and maintenance. Global trade, forward and backward linkages for import clusters, International and national auction houses.

**UNIT-II:** ***Microclimate management***: Environmental control systems in greenhouse, regulation of light through LEDs containers, substrate culture, soil decontamination techniques, aeroponics, hydroponics and vertical farming.

**UNIT-III:** ***Cultural operations***: Water and nutrient management, crop regulation, special horticultural practices under protected cultivation of rose, chrysanthemum, carnation, orchids, anthurium, gerbera, lilium, cut foliage and potted ornamental crops; plant architecture management in ornamental plants.

**UNIT-IV:** ***Advances in flower crops***: Advances in protected cultivation of important flowering (rose, chrysanthemum, carnation, gerbera, orchids, anthurium, lilium, and foliage plants (agloenema, monstera, dracaena, syngonium, pothos, diffenbachia *etc*)

**Block 2: Precision floriculture and regulations**

**UNIT-I:** ***Precision floriculture***: Precision floriculture, Principles and concepts, enabling technologies of precision floriculture, remote sensing, sensors, automation in greenhouses, solar greenhouses, retractable greenhouses. Computers and robotics, decision support systems, apps, cold chain management, use of AI for production and trade.

**UNIT-II:** ***Regulations***: PBR / IPR issues; Forward and backward linkages, 100% EOU, packaging and export standards, Cool chain Management, non-tariff barriers, APEDA regulations for export, marketing channels, auction houses, major markets.

**PRACTICAL**

1. Growing structures, basic considerations in establishment and operation of greenhouses;
2. Environmental control systems in greenhouse;
3. Containers, substrate culture, soil decontamination techniques;
4. Crop regulation;
5. Special horticultural practices under protected cultivation;
6. Precision equipments, computers and robotics in precision farming;
7. Harvest indices – harvesting, Post-harvest handling, marketing.
8. Export and cold chain management.

**TEACHING METHODS/ACTIVITIES**

- Lectures and Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

**SUGGESTED READINGS**

1. Bhattacharjee, S.K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, 2065 p.
2. Bose, T.K., Maiti, R.G., Dhua, R.S. & Das P. 1999. *Floriculture and Landscaping*. Naya Prokashan, Kolkata.
3. Reddy, S., Janakiram, T., Balaji, Kulkarni, S. & Misra, R. L. 2007. *Hi-Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi, India.

# COURSE CONTENTS: M.Sc. (Hort.) POSTHARVEST MANAGEMENT

## PHM 511 POSTHARVEST MANAGEMENT OF HORTICULTURAL PRODUCE 3(2+1)

**WHY THIS COURSE?**

Fruits and vegetables are perishable crops that suffer great losses both in quantity and quality after harvest. These produce require integrated approach to arrest their spoilage and overcome the present day challenges that assimilates millions of tons annually. Lack of postharvest awareness and absence of sufficient and functioning equipment in the postharvest chain result in serious postharvest losses in developing countries. Clear and comprehensive understanding of postharvest deteriorative factors is necessary to overcome these challenges. Pre and postharvest management such as good cultural practices, use of improved varieties, good handling practices pre and postharvest, temperature and relative humidity management, storage atmosphere management, use of permitted chemicals, design of appropriate packaging materials and storage structures are some of the control measures use in reducing postharvest losses. Hence this customized course

**AIM OF THIS COURSE**

To impart comprehensive knowledge on management of horticultural produce thus extending the post-harvest life of the produce by various treatments.

The course is organized as follows

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Postharvest management of horticultural produce | 1. Importance and scope |
| | | 2. Regulation of ripening |
| | | 3. Maturity indices for harvest |
| | | 4. Treatments for extending shelf life |
| | | 5. Handling system and marketing of horticultural crops |

**COURSE OUTCOMES:**

After successful completion of this course, the students are expected to be able to understand:

1. Regulation of ripening by use of chemicals and growth regulators.
2. Pre and Postharvest treatments for extending storage life/vase life.
3. Standards and specifications for fresh produce.

**THEORY**

**Block 1: Postharvest Management of Horticultural Produce**

**UNIT-I:** History, Importance and scope of Postharvest technology of horticultural produce. Nature and structure of horticultural produce. Pre and Postharvest losses and their causes.

**UNIT-II:** Climacteric and non-climacteric fruits. Regulation of ripening by use of chemicals and growth regulators. Control of sprouting, rooting and discoloration in vegetables.

**UNIT-III:** Maturity indices for harvest. Harvesting and harvesting tools. Curing in roots and tubers. Pre-package Operation: Pre cooling, washing, sorting, grading of horticultural perishables for local markets and export. Postharvest handling of flowers, spices, plantation crops, vegetables, medicinal and aromatic plants. Equipments for washing, sizing, grading.

**UNIT-IV:** Pre and Postharvest treatments for extending storage life/vase life. VHT, irradiation treatment, skin coating, degreening *etc*. Pre-packaging, Packaging techniques for local market and export. Standards and specifications for fresh produce.

**UNIT-V:** Postharvest handling system for horticulture crops of regional importance. Principles of transport, modes of transportation, types of vehicles and transit requirements for different horticultural produce. Marketing: Factors influencing marketing of perishable crops, marketing systems and organizations.

**PRACTICAL**

1. Study of maturity indices for harvest of fruits, vegetables, spices and plantation crops;
2. Protective skin coating with wax emulsion and pre and Postharvest treatment with fungicides, chemicals and growth regulators to extend the shelf life of fruits and vegetables;
3. Prepackaging of perishables;
4. Extension of vaselife of cut flowers by use of chemicals and growth regulators;

5. Control of sprouting of potato and onion by using growth regulators;
6. Study of modern harvesting, sorting and grading equipments;
7. Study of effect of pre-cooling on shelf-life and quality of fresh fruits, vegetables and flowers;
8. Visit to packaging centres;
9. Visit to local markets, cooperative organizations, super markets dealing with marketing of Perishables.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentation
- Group Work /seminars

**SUGGESTED READINGS**


1. Bhattacharjee S. K, and Dee L. C. (2005). Postharvest technology of flowers and ornamental plants. Pointer publishers, Jaipur.
2. Chattopadhyay S. K. (2007) Handling, transportation and storage of fruit and vegetables. Gene- Tech books, New Delhi.
3. FAO.2007. Handing and Preservation of Fruits and Vegetables by Combined methods for Rural Areas-Technical Manual. FAO Agr. Ser. Bull., 149.
4. Horticulture- Post harvest management CSIR-NISTADS
5. http://www.nistads.res.in/indiasnt2008/t6rural/t6rur13.htm
6. Kader A. A. 1992. Postharvest technology of horticultural crops. 2nd ed. university of California.
7. Paliyath G., Murr D. P., Handa, A. K. and Lurie S. (2008) Postharvest Biology and Technology of Fruits, Vegetables and Flowers, Wiley-Blackwell, ISBN: 9780813804088.
8. Post-harvest technology- MANAGE http://www.manage.gov.in/ftf-itt/prgReports/iihr.pdf
9. Pruthi J. S. 2001 (Reprint). Major spices of India crop management and Postharvest technology. ICAR, New Delhi
10. Role of post-harvest management http://www.fao.org/3/y5431e/y5431e02.htm
11. Stawley J. Kays. 1998. Postharvest physiology of perishable plant products. CBS publishers. Websites:
12. Sudheer K.P., Indira V (2007) Postharvest Technology of Horticultural Crops, Peter K.V. (Ed.), New India Publishing Agency, ISBN 9788189422431.
13. Sunil Pareek (Ed.) (2016) Postharvest Ripening Physiology of Crops, CRC Press, ISBN 9781498703802.
14. Thompson A. K. (Ed.) (2014) Fruit and Vegetables: Harvesting, Handling and Storage (Vol. 1 & 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.
15. Verma, L. R. and Joshi, V. K. (2000) Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management. Indus Publishing Company, New Delhi, India. ISBN 8173871086.
16. Wills R. B. H. and Golding, J. (2016) Postharvest: an introduction to the physiology and handling of fruit and vegetables, CABI Publishing, ISBN 9781786391483.
17. Wills R. B. H. and Golding, J. (2017) Advances in Postharvest Fruit and Vegetable Technology, CRC Press, ISBN 9781138894051.


## PHM 512 POSTHARVEST PHYSIOLOGY AND BIOCHEMISTRY OF PERISHABLES 3(2+1)

**WHY THIS COURSE?**

Immediately after harvesting, vegetables and fruits are subjected to the active processes of degradation. Numerous physiological and biochemical processes continuously change the original composition of the crop until which decrease the shelf life of the produce. Postharvest physiology is the scientific study of the physiology of living plant tissues after picking. It is very much necessary to learn about it as has direct applications to postharvest handling in establishing the storage and transport conditions that prolong shelf life. Hence this customized course.

**AIM OF THIS COURSE**

To impart comprehensive knowledge on physiology of horticultural produce after harvest and to understand different physiological processes like respiration ripening

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Biochemistry of perishable | 1. Structure and composition of horticultural produce |
| | | 2. Biochemical Changes after harvest |
| 2. | Postharvest physiology of perishables | 1. Maturity, Ripening and respiration |
| | | 2. Factors affecting shelf-life |
| | | 3. Respiratory climacteric and transpiration |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:
1. Understand about different factors affecting shelf life
2. Processes of respiration and ripening
3. Biosynthesis of ethylene and its action on ripening

**THEORY**

**Block 1: Biochemistry of Perishables**

**UNIT-I:** Introduction, biochemical structure and composition of fruits, vegetables and ornamentals.

**UNIT-II:** Biochemical changes during development and ripening. Structural Deterioration of the Produce-cell wall degradation, change in membrane lipid.: Biosynthesis of ethylene and its regulation. Ethylene action and ripening processes, its perception-action and regulation

**Block 2: Postharvest physiology of perishables**

**UNIT-I:** Determining Maturity and maturity indices. Ripening processes: events of ripening and factors affecting them

**UNIT-II:** Physiology of preharvest and postharvest; factors affecting shelf-life and quality of fruits, vegetables and ornamentals.

**UNIT-III:** Respiration: respiratory climacteric, its significance. Transpiration and water stress during postharvest. Postharvest oxidative stress: active oxygen species, AOS generation, physiological effects on horticultural commodity, control of oxidative injury.

**PRACTICAL**

1. Determination of physical parameters like specific gravity, fruit firmness *etc.*;
2. Determination of physiological loss in weight;
3. Determination of chemical constituents like sugar, starch, pigments, Vitamin C, acidity during maturation and ripening in fruits/vegetables;
4. Estimation of ethylene evolved from ripening fruits;
5. Delay/Hastening of ripening by ethylene treatments;
6. Determination of firmness, TSS, moisture, Titratable acid, sugar, protein, starch, fats, chlorophyll, carotene, anthocyanin, phenols and tannins;
7. Measurement of respiration and ethylene evaluation.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentations
- Group Work

**SUGGESTED READINGS**


1. Chadha K.L. and Pal R.K. (2015) *Managing postharvest quality and losses in horticultural crops*. Vol-1: General Issues, 1-231p Astral International (P) Ltd., New Delhi
2. Chadha K.L. and Pal R.K. (2015) *Managing postharvest quality and losses in horticultural crops*. Vol-2: Fruit Crops, 253-561p Astral International (P) Ltd., New Delhi

3. Chadha K.L. and Pal R.K. (2015) *Managing postharvest quality and losses in horticultural crops.* Vol-3: Vegetables, Flowers and Plantation Crops, 581-727p Astral International (P) Ltd., New Delhi
4. D. Mark Hodges (2003) *Postharvest Oxidative Stress in Horticultural Crops*, 1st Edition, ISBN 9781560229636
5. Ethylene biosynthesis and its response http://www.biologydiscussion.com/plants/hormonesplants/ethylene-biosynthesis-and-its-responses-plant-hormones/25986
6. Food and Agriculture Organization http://www.fao.org/home/en/
7. Paliyath G., Murr D.P., Handa, A.K. and Lurie S. (2008) *Postharvest Biology and Technology of Fruits, Vegetables and Flowers*, Wiley-Blackwell, ISBN: 9780813804088.
8. Respiration in plants http://ncert.nic.in/ncerts/l/kebo114.pdf
9. Sunil Pareek (Ed.) (2016) *Postharvest Ripening Physiology of Crops*, CRC Press, ISBN 9781498703802.
10. Thompson, A.K. 1995 *Post harvest Technology of fruits and vegetables*. Blackwell Sciences
11. Verma, L.R. and Joshi, V.K. (2000) *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.
12. Wills R.B.H. and Golding, J. (2016) *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.
13. Wills R.B.H. and Golding, J. (2017) *Advances in Postharvest Fruit and Vegetable Technology*, CRC Press, ISBN 9781138894051.

## PHM 513 PRINCIPLES AND METHODS OF FRUIT AND VEGETABLE PRESERVATION 3(2+1)

**WHY THIS COURSE?**

The fruits and vegetables are comparative higher value than cereals and more perishables. Losses in the fruits and vegetables are high and chances to reduce the waste and enhancing the employability through post-harvest processing are more. The processing includes pre-processing of fruits and vegetables before these are fit to final conversation into processed foods. The food preservation and processing industry has now become of a necessity than being a luxury. It has an important role in conservation and better utilization of fruits and vegetables. In order to avoid the glut and utilize the surplus during the season, it is necessary to employ modern methods to extend storage life for better distribution and also processing techniques to preserve them for utilization in the off season on both large scale and small scale. Hence this customized course.

**AIM OF THIS COURSE**

Understanding spoilage, underlying principles and methods of processing of fruits and vegetables.

This course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Principles and Methods | 1. Importance of fruit and vegetable processing |
| | | 2. Thermal processing |
| | | 3. Principles and methods of preservation |
| | | 4. Advanced preservation methods |
| | | 5. Food irradiation, principles |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Understand Principles and different methods of preservation.
2. Principal spoilage organisms, food poisoning and their control measures.
3. Canning of fruits and vegetables.
4. Processing equipments and layout of processing industry.

**THEORY**

**Block 1: Principles and Methods of Fruit and Vegetable Processing**

**UNIT-I:** Introduction, Historical development in food processing, type of food and causes for food spoilage. Basic principles of fruits and vegetables processing;

**UNIT-II:** Thermal processing, pH classification of foods, heat resistance of microorganism; Heat resistance of enzymes in foods, Spoilage of thermal processed food; Containers - canning, rigid tin plates and cans, aluminium cans, glass containers – types; flexible packaging materials, Composite can, specification, corrosion of cans, heat penetration into containers and methods for determination of process time.

**UNIT-III:** Effects of low temperature on fresh commodities and prepared product. Freezing preservation, freezing points of foods, slow and quick freezing, Cryogenic freezing and frozen food storage. Drying and dehydration, sun drying solar dehydration, mechanical drying types of driers, osmotic dehydration.

**UNIT-IV:** Food fermentation – alcoholic, acetic and lactic fermentation. Pickling and curing; Effect of salt on food preservation, types of salt cured products. Traditional and new products; chemical preservation, $SO_2$, benzoic acid, sorbic acid, antioxidants and antibiotics, newer preservatives. Preservation by controlling water activity – high sugar products, intermediate moisture food, food concentration.

**UNIT-V:** Food irradiation, principles, types and sources of radiation, mode of action of ionizing radiation; radiation effect on food constituents and regulation

**PRACTICAL**

1. List and cost of equipment, utensils, and additives required for small scale processing industry;
2. Chemical analysis for nutritive value of fresh and processed fruits and vegetables;
3. Preparation and preservation of fruit based beverages and blended products from fruits and vegetables;
4. Evaluation of pectin grade; preparation and quality evaluation of fruit jam;
5. Preparation of papain;
6. Blanching and its effects on enzyme;
7. Preparation of dehydrated vegetables;
8. Study of different types of spoilages in fresh as well as processed horticultural produce;
9. Study of biochemical changes and enzymes associated with spoilage;
10. Sensory evaluation of fresh and processed fruits and vegetables;
11. Visit to processing units.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Exposure visits
- Student presentation
- Group Work

**SUGGESTED READINGS**


1. Barret D.M., Somogyi L.P. and Ramaswamy H. (Eds.) (2005) *Processing Fruits: Science and Technology* (2nd Edition), CRC Press, ISBN 9780849314780.
2. FAO. (2007) *Handling and Preservation of Fruits and Vegetables by Combined Methods for Rural Areas- Technical Manual*. FAO Agricultural Services Bulletin 149.
3. Fellows, P.J. (2009) *Food Processing Technology: Principles and Practice* (3rd Edition), Woodhead Publishing, ISBN 9781845692162.
   http://agriinfo.in/default.aspx?page=topic&superid=2&topicid=2065
   http://www.cstaricalcutta.gov.in/images/CTS%20Fruits_and_Vegetables%20NSQF.pdf
   http://www.fao.org/docrep/x0209e/x0209e02.htm
4. Lal G., Siddappa G.S. and Tandon G.L. (1998) *Preservation of Fruits and Vegetables*. ICAR, ISBN 9788171640904.
5. Ramaswamy H and Marcotte M. (2006) *Food Processing: Principles and Applications*. Taylor & Francis.
6. Salunkhe D.K & Kadam S.S. (1995) *Handbook of Fruit Science & Technology: Production, Composition and Processing*. Marcel Dekker.

7. Srivastava, R.P. and Kumar, S. (2014) *Fruit and Vegetable Preservation: Principles and Practices* (3rd Edition), CBS Publishing, ISBN 9788123924373.
8. Verma, L.R. and Joshi, V.K. (2000) *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.

## PHM 521 PROCESSING OF HORTICULTURAL PRODUCE 4(2+2)

**WHY THIS COURSE?**

Postharvest system deals with ensuring the delivery of a crop from the time and place of harvest to the time and place of consumption, with minimum loss, maximum efficiency and returns to all concerned including grower, processors and consumer. The term 'system' represents a dynamic, complex aggregate of locally interconnected functions or operations within a particular sphere of activity. While, the term pipeline of operations refers to the functional succession of various operations but tends to ignore their complex interactions. Primary processing operations include washing/cleaning, sorting, grading, dehulling, pounding, grinding, packaging, soaking, winnowing, drying, sieving, whitening and milling and secondary operations include mixing, cooking, drying, frying, moulding, cutting, extrusion product preparation.

**AIM OF THIS COURSE**

This course gives an overview of status of fruit and vegetable processing in the country, objectives and importance of preservation, important constraints and different operations processing industry which helps in expansion of industry and scope for further growth in this sector.

This course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Importance and Thermal processes | 1. Scope and Importance |
| | | 2. Thermal processes |
| | | 3. Evaporation |
| 2. | Processing equipment and enzyme kinetics | 1. Processing equipment and facilities |
| | | 2. Enzyme kinetics |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to understand:

1. Unit-operations of processing.
2. Planning for domestic as well as commercial storage and processing facilities.
3. Kinetics of growth and enzyme reaction.

**THEORY**

**Block 1: Importance and Thermal processes**

**UNIT-I:** Processing unit- layout and establishment, processing tools. Quality requirements of raw materials for processing, preparation of raw material, primary processing: grading, sorting, cleaning, washing, peeling, slicing and blanching; minimal processing.

**UNIT-II:** Preparation of various processed products from fruits and vegetables, flowers; role of sugar and pectin in processed products. Freezing of fruits and vegetables. Containers, equipment and technologies in canning.

**UNIT-III:** Juice extractions, clarification and preservation, recent advances in juice processing technology, application of membrane technology in processing of juices, preparation of fruit beverages and juice concentrate. Sensory evaluation.

**Block 2: Processing equipment and enzyme kinetics**

**UNIT-I:** Dehydration of fruits and vegetables using various drying technologies and equipment, solar drying and dehydration, packaging technique for processed products.

**UNIT-II:** Quality assurance and storage system for processed products. Nutritive value of raw and processed products, plant sanitation and waste disposal. Types of horticultural and vegetables wastes and their uses, utilization of by- products from fruits and vegetables processing industries.

**PRACTICAL**

1. Handling of harvesting equipments;
2. Determination of physical and thermal properties of horticultural commodities;
3. Thermal process calculations;
4. Particle size analysis, Storage structure design;
5. Numerical problems in freezing, drying, conveying and calculations pertaining to texture and Rheology;
6. Handling of heating equipment, pulper, juice extractor, deaerator, juice filters;
7. Processing industries waste treatment;
8. Working of a canning unit;
9. Visit to commercial processing units and storage units.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentations

**SUGGESTED READINGS**

1. Cristina Ratti (2008) *Advances in Food Dehydration*, CRC Press, ISBN 9781420052527.
2. Karel M. and Lund D.B. (2003) *Physical Principles of Food Preservation* (2nd Edition), CRC Press, ISBN 9780824740634.
3. Toledo R.T. (2007) *Fundamentals of Food Process Engineering* (3rd Edition), Springer, ISBN 9780387290195.
4. Rao D.G. (2010) *Fundamentals of Food Engineering*, PHI Learning Pvt. Ltd., ISBN 9788120338715.
5. Paul S.R. and Heldman D.R. (2009) *Introduction to Food Engineering* (4th Edition), Academic Press, ISBN 9780123709004.
6. Smith P.G. (2011) *Introduction to Food Process Engineering*, Springer, ISBN 9781441976611.

## PHM 522 PACKAGING AND STORAGE OF FRESH HORTICULTURAL PRODUCE 2(1+1)

**WHY THIS COURSE?**

Being a potential source of minerals, vitamins and proteins and carbohydrates, horticultural commodities play an important role in the health and nutritional security of the people. Proper packaging and storage will utilize market surplus during glut season and thus give boost to the food industry. Horticultural produce is highly perishable particularly under tropical conditions of India. The spoilage of these commodities can be reduced to a large extent by this storage technology. Hence this customized course

**AIM OF THIS COURSE:**

To acquaint with the different storage systems and packaging systems for perishable horticultural produce.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Storage systems | 1. Importance of storage |
| | | 2. Different methods of storage |
| | | 3. Modified methods of storage |
| 2. | Packaging | 1. Importance of packaging and packaging methods |
| | | 2. New technologies in packaging |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to understand:

1. Importance of storage of horticultural produce.
2. Different methods of storage.
3. Importance of packaging for fresh horticultural produce.
4. Different methods of packaging.

**THEORY**

**Block 1: Storage Systems**

**UNIT-I:** Importance of storage of horticultural produce, present status and future scope. Principles and methods of storage – field storage structures and designs for bulk storage of horticultural produce- onion and potato *etc*. Evaporative cool chambers. Physiological changes during storage.

**UNIT-II:** Refrigerated storage - principles of refrigeration, types of refrigerants, refrigeration equipments. Cold storage rooms - Calculation of refrigeration load. Storage requirements of different fruits, vegetables, flowers. Storage disorder symptoms and control.

**UNIT-III:** Controlled or modified atmosphere (CA/MA) storage - principles, uses, structures and equipments, methods and requirements. Effect of CA storage on the physiology of stored produce. Hypobaric storage- principle, uses, and requirements. Storage disorders.

**Block 2: Packaging**

**UNIT-I:** Importance of packaging of fresh and processed horticultural produce, present status and future scope. Gaps in packaging concepts. Packaging requirements of fresh horticultural produce. Packaging patterns and methods. Food packaging systems: Different forms of packaging such as rigid, semi-rigid, flexible forms. Traditional, improved and specialized packages. Paper based packages: corrugated fibre board boxes - raw material and types of boxes. Flexible packaging materials - types and their properties. Consumer and intermediate flexible bulk containers. Testing of flexible packaging material. Barrier properties of packaging materials.

**UNIT-II:** New technology in packaging - stretch wrapping system, vacuum packaging, gas packaging, controlled atmosphere (active and intelligent) packaging, vibra packaging, skin packaging, shrink packaging, form-fill-seal packaging, Packaging machines. Quality control and safety aspects of packaging materials.

**PRACTICAL**

1. Study of special storage structures for bulk storage of onion/potato, *etc.*;
2. Study of storage behaviour of different fruits and vegetables in zero energy cool chamber;
3. Determination of refrigeration requirements (capacity) for given quantity of fruits and vegetables;
4. Study of storage behaviour of different fruits and vegetables in cold room;
5. Study of chilling injury and storage disorders;
6. Study of shelf-life of fruits and vegetables in modified atmosphere packaging. Visit to special; storage structures, cold storage units. Study of types of packaging materials, types of plastic films and their properties;
7. Determination of water vapour transmission rate (WVTR) and gas transmission rate (GTR) of packaging material;
8. Applications of packaging material for fresh fruits and vegetables, beverages, spice products;
9. Determination of shelf-life of fresh products in different types of packages;
10. Study of packaging machines - vacuum packaging machine, shrink wrapping machine, double seamer, *etc*. Visit to packaging unit.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentations
- Group Work /seminars

**SUGGESTED READINGS**


1. Ahvenainen R. (2003) *Novel Food Packaging Techniques*, CRC Press, ISBN 0849317894.
2. Burg S. P (Ed.) (2004) *Postharvest physiology and hypobaric storage of fresh produce*, CABI Publishing, ISBN 0851998011.
3. Chattopadhya, S. K. (2007) *Handling, transportation and storage of fruits and vegetables*. Gene-Tech books, New Delhi.
4. Coles R., McDowell D. and Kirwan M. J. (Eds.) (2003). *Food Packaging Technology*, Blackwell Publishing, ISBN 1841272213.

5. https://energypedia.info/wiki/ Cold_Storage_of_ Agricultural_Products, Low cost storage technologies for preservation-IARI.
6. http://www.iari.res.in/download/pdf/story4_eng.pdf
7. Mahadevaiah, M and Gowramma, RV. (1996). *Food packaging materials*. Tata McGraw Hill.
8. Painy, F.A. (1992) *A handbook of food packaging*. Blackie Academic.
9. Pantastico, B. (1975) *Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables*. AVI Publ.
10. Rao Chandra Gopala (2015) *Engineering for Storage of Fruits and Vegetables*; Academic Press, 1st Edition.
11. Robertson G. L. (Ed.) (2010) *Food packaging and shelf life: a practical guide*, CRC Press, ISBN 9781420078442.
12. Storage practices and structures UCANR http://ucanr.edu/datastoreFiles/234-1303.pdf
13. Thompson A. K. (2010) *Controlled atmosphere storage of fruits and vegetables* (2nd Edition), CABI International, ISBN 9781845936464.
14. Thompson A.K. 2010, *Controlled Atmosphere Storage of Fruits and Vegetables*, CABI Publishing; 2nd revised edition.
15. Wilson C.L. (Ed.) (2007) *Intelligent and active packaging for fruits and vegetables*, CRC Press, ISBN 9780849391668.


## PHM 523 LABORATORY TECHNIQUES IN POSTHARVEST MANAGEMENT 3(1+2)

**WHY THIS COURSE?**

To familiarize with the conventional analysis of raw and processed food products of all commodity technologies used for routine quality control in food industry, and their role on nutritional labeling. To develop an understanding and methodologies of instrumental techniques in food analysis used for objective methods of food quality parameters.

**AIM OF THIS COURSE**

To familiarise with advances in instrumentation and Postharvest management

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to understand:

1. Techniques and instrumentation used in food industry.
2. Analysis of pesticide residues.
3. Quality analysis of processed fruits and vegetables.
4. Principles of chromatography and Spectrophotometry.
5. Non-destructive quality evaluation.

**THEORY**

**Block 1: Laboratory Techniques in Postharvest Management**

**UNIT-I:** Rheological techniques and instrumentation used in food industry. Analysis of food additives like food colour, antioxidants, emulsifier, *etc*.

**UNIT-II:** Analysis of pesticide residues, metallic contaminants, aflatoxin. Analysis of food flavours.

**UNIT-III:** Quality analysis of processed fruits and vegetables, coffee, tea and spices. Identification and enumeration of microbial contaminants.

**UNIT-IV:** Principles of chromatography (GC, GCMS, HPLC, LCMS), spectrophotometry (Atomic absorption spectrophotometer, ICAP spectrophotometer), ICP-MS, ICPOES, NMR, ESR, amino acid analyser, flame photometry, electrophoresis,

**UNIT-V:** Colour measurement in foods, IRGA, Radio-isotopic techniques. Non-destructive quality evaluation (NDQE)- e-nose, e-tongue, machine vision. electrophoresis.

**PRACTICAL**

1. Sample preparation for quality analysis. Energy calculation, sample calculations;
2. Texture analysis, Rheology of different foods;
3. Instrumental colour analysis;
4. Sensory evaluation and microbiological examinations of fresh and processed products;
5. Estimation of tannin/phytic acid by spectrometric method;
6. Moisture and fat analysis by NIR spectroscopy;
7. Separation and identification of sugars in fruit juices;

8. Separation and identification of carotenoids by column chromatography;
9. Estimation of respiration in fruits and vegetables;
10. Flavour profile in essential oils using GC;
11. Identification and determination of organic acids by HPLC;
12. Capsaicin content and Scoville Heat Units in chillies;
13. Heavy metal analysis using atomic absorption spectrometry;
14. Residue analysis.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentations

**SUGGESTED READINGS**

1. Lundanes, E., Reubsaet, L. and Greibrokk, T. (2013). *Chromatography: Basic Principles, Sample Preparations and Related Methods*, ISBN-13: 978-3527336203, Wiley VCH
2. Mark F. Vitha (2016). *Chromatography: Principles and Instrumentation,* John Wiley & Sons, ISBN 9781119270881
3. Nielsen, S. Suzanne (2010) *Introduction to Food Analysis*, ISBN 978-1-4419-1478-1, Springer.
4. Ranganna S. (2001) *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw-Hill ISBN 9780074518519.
5. Semih Otles (Editor) (2016) *Methods of Analysis of Food Components and Additives* (Chemical & Functional Properties of Food Components) CRC Press, ISBN-13: 978- 1138199149.

## PHM 524 PACKAGING AND STORAGE OF PROCESSED HORTICULTURAL PRODUCE 2(1+1)

**WHY THIS COURSE?**

Horticulture industry is dominated by market interaction in terms processing and their packaging. Much of the total cost of produce is determined by nature of packaging and packaging material used. Packaging cost sometimes exceed the raw material cost, depending on the nature of the produce, time and period. This course helps in understanding the packaging interaction with produce, environment and time. And it also helps to take informed decision on package requirement for horticulture produce.

**AIM OF THIS COURSE**

To acquaint with the different and packaging systems for processed horticultural produce.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Packaging principles & functions | 1. Functions of packaging |
| | | 2. Basic principles of packaging materials |
| | | 3. Manufacture of packaging materials |
| | | 4. Types of packaging materials |
| | | 5. Testing of packaging |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to understand:

1. Importance of packaging for processed horticultural produce.
2. Different methods of packaging, methods and their applications in food industry.

**THEORY**

**Block 1: Packaging principles & functions**

UNIT-I: Functions of packaging; Type of packaging materials; Selection of packaging material for different foods; Selective properties of packaging film; Methods of packaging and packaging equipment.

**UNIT-II:** Mechanical strength of different packaging materials; Printing of packages; Barcodes & other marking; Interactions between packaging material and foods; Environmental and cost consideration in selecting packaging materials.

**UNIT-III:** Manufacture of packaging materials; Potential of biocomposite materials for food packaging; Packaging regulations; Packaging and food preservation; Disposal of packaging materials.

**UNIT-IV:** Metal cans: types, fabrication, lacquering and tin quality. Double seaming technology - defects and causes. Glass containers– types; testing quality- thermal shock resistance, thermal shock breakage, impact breakage

**UNIT-V:** Testing of packaging; Rigid and semi rigid containers; Flexible containers; Sealing Equipment. Labeling; Aseptic and shrink packaging; Secondary and transport packaging. Different packaging systems for dehydrated foods, frozen foods, dairy foods, fresh fruits and vegetables.

**PRACTICAL:**

1. Testing of packaging material: compression strength/drop test/thermal shock test/seam evaluation/seam defects;
2. Determination of shelf-life of processed products in different types of packages;
3. Study of packaging machines - vacuum packaging machine, shrink wrapping machine, double seamer, *etc.*;
4. Visit to packaging units.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentations
- Group Discussions

**SUGGESTED READINGS**

1. Ahvenainen R. (2001) *Novel Food Packaging Techniques*. CRC.
2. Ahvenainen R. (2003) *Novel Food Packaging Techniques*, CRC Press, ISBN 0849317894.
3. Coles R., McDowell D. and Kirwan M. J. (Eds.) (2003) *Food Packaging Technology*, Blackwell Publishing, ISBN 1841272213.
4. Joseph, H. Hotchkiss, 1987, *Food and Packaging Interactions*, (ACS symposium series -365, April 5-10, 1987, American Chemical Society, Washington DC. 1988)
5. Mahadevaiah, M and Gowramma, RV. (1996) *Food packaging materials*. Tata McGraw Hill.
6. Painy, F.A. (1992) *A handbook of food packaging*. Blackie Academic.
7. Robertson, G. L. (Ed.) (2010) *Food packaging and shelf life: a practical guide*, CRC Press, ISBN 9781420078442.
8. Thompson, A.K. 2010, *Controlled Atmosphere Storage of Fruits and Vegetables*, CABI Publishing; 2nd revised edition.
9. Wilson C.L. (Ed.) (2007) *Intelligent and active packaging for fruits and vegetables*, CRC Press, ISBN 9780849391668.

## PHM 531 QUALITY ASSURANCE, SAFETY AND SENSORY EVALUATION OF FRESH AND PROCESSED HORTICULTURAL PRODUCE 3(2+1)

**WHY THIS COURSE?**

The quality of fresh horticultural commodities is a combination of characteristics, attributes, and properties that give the commodity value for food (fruits and vegetables) and enjoyment (ornamentals). Producers are concerned that their commodities have good appearance and few visual defects, but for them a useful cultivar must score high on yield, disease resistance, ease of harvest, and shipping quality. To receivers and market distributors, appearance quality is most important; they are also keenly interested in firmness and long storage life. Although consumers buy on the basis of appearance and feel, their satisfaction and repeat purchases are dependent upon good edible quality. Assurance of safety of the products sold is extremely important to the consumers. Hence this customized course.

**AIM OF THIS COURSE**

To understand the quality and safety management system and the process of sensory analysis for horticultural products

This course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Quality Assurance | 1. Concept of quality |
| | | 2. Food laws and regulations |
| 2. | Safety | 1. Food safety |
| | | 2. Quality management |
| 3. | Sensory Evaluation | 1. Introduction to sensory Evaluation |
| | | 2. Methods of sensory evaluation |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to understand:

1. Concepts of quality management.
2. Food laws and regulation in India.
3. Export specification and guidelines by APEDA.
4. Consumer perception of safety and Ethics in food safety.

**THEORY**

**Block 1: Quality Assurance**

**UNIT-I:** Concept of quality: Quality attributes- physical, chemical, nutritional, microbial, and sensory; their measurement and evaluation. Concepts of quality management: Objectives, importance and functions of quality control; Quality management systems in India; Sampling procedures and plans.

**UNIT-II:** Food laws and regulations in India, Quality management standards, ISO,BIS, PFA, AGMARK and QMS standards, quality system components and their requirements.

**Block 2: Safety**

**UNIT-I:** Food safety and standards act (FSSA, 2006); Strategies for compliance with international agri-food standards; Export specification and guidelines by APEDA. Hazard analysis and critical control points (HACCP), design and implementation of an HACCP system, steps in the risk management process. Traceability in food supply chains

**UNIT-II:** Organic Certification, GAP, GMP, TQM. Indian and International quality systems and standard like, Codex Alimentarius, ISO, *etc*. Consumer perception of safety; Ethics in food safety.

**Block 3: Sensory Evaluation**

**UNIT-I:** Introduction to sensory analysis; general testing conditions, Requirements of sensory laboratory; organizing sensory evaluation programme. Selection of sensory panellists; Factors influencing sensory measurements; Sensory quality parameters -Size and shape, texture, aroma, taste, colour and gloss; Detection, threshold and dilution tests. Different tests for sensory evaluation– discrimination, descriptive, affective; Flavour profile and tests; Ranking tests;

**UNIT-II:** Methods of sensory evaluation of different food products. Designing of experiments. Handling and interpretation of Data. Role of sensory evaluation in product optimization. Relationship between objective and subjective methods. Sensory analysis for consumer evaluation. Computer-aided sensory evaluation of food and beverage

**PRACTICAL**

1. Analysis for TSS, pH, acidity, sugars, pectic substances, minerals, vitamin C, carotene, alcohol, benzoic acid and SO2 contents, yeast and microbial examination in processed products;
2. Demonstration of measurement of vacuum/pressure, head space, filled weight, drained weight, cut-out analysis and chemical additives;
3. Moisture content, rehydration ratio and enzymatic/non-enzymatic browning in dehydrated products;
4. Analysis of spices for quality parameters. Evaluation of processed products according to FSSAI specification;
5. Selection and training of sensory panel;
6. Identification of basic taste, odour, texture and colour;
7. Detection and threshold tests; Ranking tests for taste, aroma, colour and texture; Sensory evaluation of various horticultural processed products using different scales, score cards and tests, Hedonic testing;
8. Estimation of colour and texture; optimising a product by sensory analysis;

9. Studying relationship between objective and subjective methods.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentation

**SUGGESTED READINGS**

1. Amerine, M. A., Pangborn, R. M.& Rosslos, E. B. (1965). *Principles of Sensory Evaluation of Food*. Academic Press.
2. DGHS Manual 8: *Manual of Methods of Analysis of Foods-Food Additives*.
3. Early R. (1995) *Guide to Quality Management Systems for the Food Industry*, Springer, ISBN 9781461358879.
4. https://en.wikipedia.org/wiki/Sensory_analysis.
5. https://link.springer.com/chapter/10.1007/978-1-4757-5112-3_5
6. https://www.foodqualityandsafety.com/
7. Krammer, A and Twigg, B.A. (1973) *Quality Control in Food Industry*.Vol.I, II.AVI Publ.
8. Lawless, Harry T., Heymann, Hildegarde (2010). *Sensory Evaluation of Food: Principles and Practices*, Springer, ISBN 9781441964885.
9. Patricia A. Curtis (2005) *Guide to Food Laws and Regulations*, Wiley-Blackwell, ISBN 9780813819464.
10. Ranganna, S. (2001) *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw-Hill ISBN 9780074518519.
11. Sarah, E. Kemp, Tracey Hollowood, Joanne Hort (2009). *Sensory Evaluation: A Practical Handbook*, Wiley- Blackwell Publisher, ISBN 9781405162104.
12. *The Food Safety and Standards act, 2006 along with Rules & Regulations 2011*, Commercial Law Publishers (India) Pvt. Ltd.

## PHM 532 FUNCTIONAL FOODS FROM HORTICULTURAL PRODUCE 2(2+0)

**WHY THIS COURSE?**

Functional foods are foods that have a potentially positive effect on health beyond basic nutrition. This course examines the rapidly growing field of functional foods in the prevention and management of chronic and infectious diseases. It attempts to provide a unified and systematic account of functional foods by illustrating the connections among the different disciplines needed to understand foods and nutrients, mainly: food science, nutrition, pharmacology, toxicology and manufacturing technology. Advances within and among all these fields are critical for the successful development and application of functional foods

**AIM OF THIS COURSE**

To familiarise with functional foods from horticultural produce This course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Functional food and importance | 1. Introduction, Sources and classification |
| | | 2. Functional Ingredients |
| 2. | Bioactive Compounds | 1. Introduction and classes of bioactive compounds |
| | | 2. Mechanism of Neuroprotection |
| 3. | Neutraceuticals | 1. Introduction, classification, role and health benefits |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to understand:

1. Importance of functional foods.
2. Functional ingredients and their properties.
3. Classes of bioactive compounds present in fruits and vegetables.
4. Mechanism of neuroprotection by bioactive compounds.
5. Importance of Nutraceuticals.

**THEORY**

**Block 1: Functional food and importance**

**UNIT-I:** Functional foods- Introduction, definition, history; Importance, relevance and need of functional foods. Sources and classification of functional foods. Importance of horticultural produce as functional foods. Functional foods derived from fruits, vegetables, medicinal and aromatics.

**UNIT-II:** Functional ingredients and their properties. Therapeutic potential and effects of horticultural produce; Herbs, herbal teas, oils, *etc.* in the prevention and treatment of various diseases. Effect of preservation and processing on functional properties of horticulture produce.

**Block 2: Bioactive Compounds**

**UNIT-I:** Introduction, Classes of bioactive compounds present in fruits and vegetables. Polyphenols: Phenolic acid, Stilbenes, Flavonoids, Lignin, Coumarin, Tannin *etc.* –their chemistry, source, bioavailability, interaction in food systems; changes during storage and processing. Alkaloids; Nitrogen Containing Compounds; Sulphur compounds; phytosterols; carotenoids; dietary fibres *etc.*–their chemistry, source, bioavailability, interaction in food systems; changes during storage and processing.

**UNIT-II:** Mechanism of neuroprotection by bioactive compounds. Techniques of Extraction, purification and concentration of bioactive compounds from fruits and vegetables. Bioactive compound and health benefits. Incorporation of bioactive compounds in foods.

**Block-3: Neutraceuticals**

**UNIT-I:** Nutraceuticals- Introduction, classification of nutraceuticals, dietary supplements, fortified foods, functional foods and phytonutraceuticals. Role of medicinal and aromatic plants in nutraceutical industry. Health benefits of phytoneutraceuticals.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignment (Reading/Writing)
- Exposure visits
- Student presentation

**SUGGESTED READINGS**

1. *Interventions in the Processing of Fruits and Vegetables*, Apple Academic Press, ISBN 9781771885867.
2. Rosa L.A., Alvarez-Parrilla E. and Gonzalez-Aguilar G.A. (2009) *Fruit and Vegetable Phytochemicals: Chemistry, Nutritional Value and Stability*, Wiley-Blackwell, ISBN 9780813803203.
3. Vattem, D.A (2016). *Functional Foods, Nutraceuticals and Natural Products Concepts And Applications.* DEStech Publications, Inc. ISBN No. 978-1-60595-101-0.
4. Watson, R.R. and Preedy, V. (2009). *Bioactive Foods in Promoting Health: Fruits and Vegetables* (1st Edition), Academic Press, ISBN 9780123746283.

## PHM 533 MARKETING AND ENTREPRENEURSHIP IN POST HARVEST HORTICULTURE 2(1+1)

**WHY THIS COURSE?**

To develop marketing strategies and equip individuals to start their own food service. To develop Techniques for the development of entrepreneurial skills, positive self-image and locus of control

**AIM OF THIS COURSE**

To understand the market channel and appraise entrepreneurship opportunity in postharvest operations.

This course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Marketing and entrepreneurship in processing industry | 1. Entrepreneurship |
| | | 2. Business Plan |
| | | 3. MSME Enterprise |
| | | 4. Marketing |
| | | 5. Institutional supports |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to understand:

1. Concept of entrepreneurship.
2. Writing Business Plan.
3. Steps in establishment of MSME Enterprise.
4. Marketing management.
5. Institutional support to Entrepreneurship.

**THEORY**

**UNIT-I:** Entrepreneurship– Concept, need for entrepreneurship- Types of entrepreneurs-entrepreneurial opportunities in horticultural processing sector-Government schemes and incentives for promotion of entrepreneurship in processing sector

**UNIT-II:** Writing Business Plan- Business Plan Format for Small and micro Enterprises-Generation, incubation and commercialization of business ideas- Environment scanning and opportunity identification

**UNIT-III:** Steps in establishment of MSME Enterprise- Planning of an enterprise- Formulation and project report-Meaning- Importance Components and preparation. Government Formalities and Procedures.

**UNIT-IV:** Marketing potential of processed products at domestic and international level- Marketing management-Marketing functions, market information and market research- Problems in marketing of processed products-Demand and supply analysis of important processed products-Marketing channels - Marketing strategy (product strategy and pricing strategy)- Supply chain management - Meaning, importance, advantages, supply chain management of important processed products

**UNIT-V:** Institutional support to Entrepreneurship Role of Directorate of Industries, District Industries, Centres (DICs), Industrial Development Corporation (IDC), State Financial corporation (SFCs), Commercial banks Small Scale Industries Development Corporations (SSIDCs), Khadi and village Industries Commission (KVIC), National Small Industries Corporation (NSIC), Small Industries Development Bank of India (SIDBI)

**PRACTICAL**

1. Consumer Behaviour towards Processed Foods;
2. An Empirical Test-Carrying out the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of successful Enterprises-
3. Constraints in setting up of horti based industries;
4. Field visits to study any one of the Local Financial Institutions to study the MSME Policies;
5. Preparation of business plan and proposal writing-Project evaluation techniques- Discounted and undiscounted techniques;
6. Case studies of successful entrepreneurs.

**TEACHING METHODS/ ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Exposure visits
- Student presentation

**SUGGESTED READINGS**


1. Adhikary, M.M. (2014). *Enterprise and Entrepreneurship for Agri-Business Management and Planning*. Daya Publishing House, New Delhi.
2. Bhaskaran, S. (2014). *Entrepreneurship Development & Management*. Aman Pub. House.
3. Choudhury, M. and Barua N. (2014). *Marketing of Processed Fruit and Vegetable*. Daya Publishing House, New Delhi.
4. Gaur, SC 2012. *Handbook of Agro Food Processing and Marketing*. Agrobios. Jodhpur
5. Kadam and Bishe (2018). *Textbook on Agricultural Entrepreneurship*. Narendra publishing house. New Delhi
6. Sudheer KP and Indira, V. (2018) *Entrepreneurship and Skill Development in Horticultural Processing*. New India Publishing Agency. New Delhi
7. Sudheer, K P and Indira, V. (2018) *Entrepreneurship Development in Food Processing*. New India Publishing Agency. New Delhi.

# COURSE CONTENTS: Ph.D. POSTHARVEST MANAGEMENT

## PHM 611 RIPENING AND SENESCENCE OF FRUITS AND VEGETABLES 2(1+1)

**WHY THIS COURSE?**

Fleshy fruit experiences profound physiological, biochemical, and structural modifications during ripening to facilitate seed dispersal and to become attractive and nutritious for human consumption. The metabolic networks regulating fruit ripening are very complex, and ethylene appears to be a key factor acting in concert with other environmental signals and endogenous factors. The classical distinction between climacteric and nonclimacteric ripening is now questionable, as different patterns of synthesis and sensitivity to ethylene may operate in the ripening of different fruits. In recent years, much progress has been done in the characterization of the main biochemical pathways implicated in the different ripening associated processes and in the identification of key genes controlling these events. This course highlights current understanding and advances in the regulation of fruit ripening and key metabolic pathways associated with the different ripening-related processes, with emphasis on their impact on fruit quality.

**AIM OF THE COURSE**

To impart knowledge about physiological and molecular changes during senescence and ripening.

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to understand:

1. Physiological, biochemical and structural changes during senescence and ripening.

**THEORY**

**Block 1:**

**UNIT-I:** Environmental factors influencing senescence, ripening and post-harvest life of fruits, flowers and vegetables.

**UNIT-II:** Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening. Senescence associated genes and gene products.

**UNIT-III:** Functional and ultra structural changes in chloroplast membranes, mitochondria and cell wall during senescence and ripening.

**UNIT-IV:** Ethylene biosynthesis, perception and molecular mechanism of action; regulatory role of ethylene in senescence and ripening, biotechnological approaches to manipulate ethylene biosynthesis and action.

**UNIT-V:** Alternate post-harvest methodology and quality attributes. Scope for genetic modification of post-harvest life on flowers and fruits. Uses of GM crops and ecological risk assessment.

**PRACTICAL**

1. Physiological and biochemical changes during senescence and ripening;
2. Estimation of ethylene during senescence and ripening;
3. Determination of Reactive Oxygen Species and scavenging enzymes;
4. Measurement of dark and alternate respiration rates during senescence and ripening;
5. Estimation of ripening related enzyme activity, celluloses, pectin methyl esterases, polygalacturonase, *etc.*

**SUGGESTED READINGS**


1. Bartz, J.A. and Brecht, J.K. 2003.*Post harvest physiology and pathology of vegetables*. Marcel Dekker Inc.
2. Davis, P.J. 2004. *Plant Hormone: Biosynthesis, Signal transduction and action*. Kluwer Academic Publishers.
3. Dris, R. and Jain, S.M. 2004. *Production practices and quality assessment of food crops*, Vol. 4: *Post-harvest treatment and Technology*. Kluwer Academic Publisher.
4. Khan, N.A. 2006.*Ethylene action in plants*. Springer Verlag.
5. Knee, M. 2002. *Fruit Quality and its Biological Basis*. Sheffield Academic Press, CRC Press.
6. Nooden, L.D. 2004. *Plant Cell Death Processes*. Elsevier Science, USA.

7. Paliyath, G. Murr, D.P., Handa, A.K. and Lurie, S. 2008. *Post-harvest biology and technology of fruits, Vegetables and Flowers*. Blackwell Publishing, Iowa, USA.
8. Seymour, G., Taylor, J. and Tucker, G. 1993. *Biochemistry of fruit ripening*. Edited Chapman and Hall, London.
9. Valpuesta, V. 2002. *Fruit and vegetable biotechnology*. Woodhead Publishing Limited, Cambridge, England.

## PHM 612 RECENT TRENDS IN FOOD PRESERVATION 2(1+1)

**WHY THIS COURSE?**

Commendable production with short storage life and strategic selling limits the produce to huge loss after harvest. To prevent the postharvest loss preservation of produce with appropriate technique enhances the finished product shelf life nearly 10 to 30 times. Food processing combines raw food ingredients to produce marketable food products that can be easily prepared and served by the consumer. Emerging technologies which have already found in the food industry or related sector are High pressure processing, pulsed electric fields, ultrasound, and cold plasma. The basic principles of these technologies as well as the state of the art concerning their impact on biological cells, enzymes, and food constituents.

**AIM OF THIS COURSE**

The present subject imparts knowledge on recent advancement in food preservation technologies. The basic principles of preservation technologies as well as the state of the art concerning their impact on biological cells, enzymes and food constituents. Current and potential applications will be discussed, focusing on process-structure-function relationships, as well as recent advances in the food process development that make foods.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Hurdle technology and recent advances | 1. Hurdle technology |
| | | 2. Thermal and Non-thermal technology |
| | | 3. Recent food preservation techniques |
| 2. | Enzyme applications and quality parameters | 1. Enzyme and their applications |
| | | 2. Quality specifications and standards |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Understand the latest methods and techniques in preservation of food particularly of horticultural produce

**THEORY**

**Block 1: Hurdle technology and recent advances**

**UNIT-I:** Hurdle technology, Principles of Hurdle Technology, Minimally Processed foods, Intermediate moisture foods, role of water activity in food preservation, Chemicals and biochemicals used in Food Preservation- Natural food preservatives, bacteriocins.

**UNIT-II:** Thermal and Non-thermal technology, Advanced Thermal and Nonthermal Technology-Pulsed electric field, microbial inactivation, application, present status and future scope. Fundamentals and Applications of High Pressure Processing to Foods, Advances in Use of High Pressure to Processing and Preservation of Plant Foods, Commercial High-Pressure Equipment. Food Irradiation - an Emerging Technology.

**UNIT-III:** Recent food preservation techniques, Ultraviolet Light and Food Preservation; Microbial Inactivation by Ultrasound; Use of oscillating Magnetic Fields. Nonthermal Technologies in Combination with Other Preservation Factors. Preservation by ohmic heating-Advances in Ohmic Heating and Moderate Electric Field (MEF) Processing; Radio- Frequency Heating in Food Processing; Current State of Microwave Applications to Food Processing. Supercritical Fluid Extraction: An Alternative to Isolating bioactive compounds.

**Block 2: Enzyme applications and quality parameters**

**UNIT-I:** Enzyme and their applications. Enzyme and their application in food processing, Principles of food biotechnology, fermentation and enzyme mediated food processing, production of high value products such as Single Cell Protein, nutritional additives, pigments and flavours.

**UNIT-II:** Quality specifications and standards. Quality parameters and specifications, Food laws and standards, HACCP, FSSAI amendments, ISO, FDA.

**PRACTICAL**

1. Determination of thermal resistance of food spoilage microorganisms;
2. Determination of thermal death curve;
3. Thermal process calculations;
4. Demonstration of hurdle approaches in fruits and vegetables preservation. Enumerate the hurdle approaches in food processing;
5. Detection of microbes in each hurdle;
6. Study of shelf life of fresh cut produce in each hurdle;
7. Study of fresh cut produce packing, storage temperature and microbial interaction;
8. Study of thermal and non-thermal application in food preservation;
9. Study of moisture content in food their water activity;
10. Demonstration of microwave technology in fresh produce preservation and drying;
11. Determination of dry matter content in food using microwave technology;
12. Study the use of enzymes in different fruit juice extraction, quantification, time- Pectinase/ cellulose & others;
13. Incubation techniques of enzymes using fermenter for juice extractions;
14. Group discussions on current market potential of hurdle technology – Pros and cons;
15. Visit to advanced food processing unit;
16. Visit to SCFE unit.

**TEACHING METHODS/ ACTIVITIES**

- Lectures
- Assignment (Reading/Writing)
- Student presentation

**SUGGESTED READINGS**


1. Barbosa, C.G.V., Pothakamury, U.R., Palou, E. and Swanson, B.G. (1998) *Nonthermal Preservation of Foods*, Marcel Dekker Inc., ISBN 9780824799793.
2. http://www.ijpab.com/form/2017%20Volume%205,%20issue%206/IJPAB-2017-5-6-363-371.pdf
3. http://www.sciencepublishinggroup.com/specialissue/specialissueinfo?jo
4. https://www.elsevier.com/books/advances-in-cold-plasma-applications-for-food-safety-and-preservation/bermudez-aguirre/978-0-12-814921-8
5. https://www.omicsonline.org/conferences-list/food-processing-technologies-and-advances-infood-preservation
6. Karel, M. and Lund, D.B. (2003). *Physical Principles of Food Preservation* (2nd Edition), CRC Press.
7. Sun Da-Wen (Ed.) (2014). *Emerging Technologies for Food Processing* (2nd Edition), Elsevier, ISBN 9780124114791.
8. Tewari, G. and Juneja, V. (2007). *Advances in thermal and nonthermal food,* Blackwell Publishing, ISBN 9780813829685.


## PHM 613 SUPPLY CHAIN MANAGEMENT OF PERISHABLES 2 (2+0)

**WHY THIS COURSE?**

Supply chain management is the management of the flow of goods and services and includes all processes that transform raw materials into final products. It involves the active streamlining of a business's supply-side activities to maximize customer value and gain a competitive advantage in the marketplace. SCM represents an effort by suppliers to develop and implement supply chains that are as efficient and economical as possible. Supply chains cover everything from production to product development to the information systems needed to direct these undertakings. Because of this, effective supply chain management also requires change management, collaboration and risk management to create alignment and communication between all the entities.

**AIM OF THIS COURSE**

To understand the intricacies of perishable supply chain and its management.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Supply chain management of perishables | 1. Introduction |
| | | 2. Intrinsic Issues |
| | | 3. Support system in supply chain- - Infrastructure |
| | | 4. Support system in supply chain- Finance |
| | | 5. Support system in supply chain- Government |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Can identify the problems related waste treatments and disposal methods

**THEORY**

**Block 1: Supply chain management of perishables**

**UNIT-I:** Introduction. Role of supply chain and logistics, Challenges faced in supply chain, Input suppliers, Farm output: Market intermediaries, Processors, Retailers.

**UNIT-II:** Intrinsic Issues: Perishability, Quality, Grading, Risk: Sources of risk, Classification of Agricultural risk- Production risk, Market and Price risk. Management of risk.

**UNIT-III:** Support system in supply chain- Infrastructure: definition, role. Transport network, Cold storage, organised market *etc*. Information technology-Enterprise resource planning, EChoupal, Mobile Technology, web portal on agri-market information.

**UNIT-IV:** Support system in supply chain- Financial Systems: Introduction, Role and Relevance, Problems in Synchronization, Role of Technology; Credit Structure in India - Reserve Bank of India (RBI), NABARD; Commodity Markets, Corporates in Agribusiness.

**UNIT-V:** Support system in supply chain- Role of Government: Introduction; Agencies- As a Direct Player. Measures for improving supply chain and its effectiveness, involvement of organized retailers.

**PRACTICAL**

1. Present scenario of supply chain management;
2. Case Study: Supply chain management of fruits and vegetables in Safal daily fresh/APMC/Reliance Fresh/Amul/D-Mart/Spencer Retail/Vipani/Farmers Bazars/Farm Fresh/Apni Mandi, *etc*. based on regional importance.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignment (Reading/Writing)
- Student presentation.

**SUGGESTED READINGS**

1. Chandrasekaran, N. and Raghuram, G. (2014) *Agribusiness Supply Chain Management*, CRC Press, ISBN 9781466516755.
2. Chopra, S. and Meindl, P. (2007) *Supply chain management: strategy, planning, and operation* (3rd Ed.), Pearson Education, Inc., ISBN 0132086085.
   http://supplychaininsights.com/
   http://www.scmr.com/
   http://www.supplychain247.com/
   http://www.supplychainnetwork.com/
   https://blog.kinaxis.com/

## PHM 621 MANAGEMENT AND UTILIZATION OF HORTICULTURAL PROCESSING WASTE 3(3+0)

**WHY THIS COURSE?**

Processing of fruit and vegetables generates varying level and kinds of wastage that can be managed differently. With the rapid progress in establishment of processing industries in our country on account of liberal government policies, the importance of waste management has become an essential and integral part of plant design as the inappropriate disposal of wastage has already caused great loss to environment and public health. Food processing is a capital intensive, high energy and water consuming, and moderate to highly polluting industry. However, one can minimize adverse effects on environment and public health and may also augment profit of processing unit by judicious disposal and utilization of waste materials. They can be used in composting, cattle feeding and biogas generation and certain types may also be utilized in production of value added products.

**AIM OF THIS COURSE**

Understanding the utilization and efficient management of waste from horticultural processing industry.

The course is organized as follows:

| S.No. | Blocks | Introduction |
|---|---|---|
| 1. | Waste treatment and disposal methods | 1. Waste treatment processes |
| | | 2. Waste disposal methods |
| | | 3. Recovery of useful products |
| 2. | Valorisation of wastes | 1. Treatment of solid and liquid waste |
| | | 2. |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Can identify the problems related waste treatments and disposal methods.
2. Problem related valuation of waste and recycling of waste.

**THEORY**

**Block 1: Waste treatment and disposal methods**

**UNIT-I:** Introduction: Waste and its consequences in pollution and global warming. Need for waste management. Waste and its classifications and characterization-sampling methods, analysis and standards for waste discharge. Importance of point and nonpoint sources of wastes, Solid and liquid wastes.

**UNIT-II:** Waste treatment processes: BOD, COD, DO, TS VS, ash, and different **UNIT-**operations in waste treatment processes.

**UNIT-III:** Waste disposal methods: Nature of waste from processing industry and their present disposal methods. Waste segregation, Primary secondary and tertiary waste treatment processes, Conventional and non-conventional waste treatment processes, aerobic and anaerobic waste treatment processes.

**Block 2: Valorisation of wastes**

**UNIT-I:** Recovery of useful products: Valorization of wastes: Recovery of useful products and by-products from waste, viz., organic acids, bioethanol, biobutanol, colour, essence, pectin, oils, *etc.* animal feed and single cell protein.

**UNIT-II:** Treatment of solid and liquid waste: Technology of treatment of solid and liquid wastes from fruit and vegetable industries. Immobilized bioreactor in waste treatment. Anaerobic bioreactor and energy production. Circular economics and waste management.

**TEACHING METHODS / ACTIVITIES**

- Lectures
- Assignments (Reading/Writing)
- Student presentations

## SUGGESTED READINGS


1. Arvanitoyannis I. S. (2008) *Waste Management for the Food Industries*, Academic Press, ISBN 9780123736543.
   http://www.3rmanagement.in/service/horticulture-waste-management/
   https://www.cabdirect.org/cabdirect/abstract/20153005486
2. Joshi V. K. and Sharma S. K. (2011) *Food Processing Waste Management: Treatment and Utilization Technology*, New India Publishing Agency, ISBN 9789380235592.
3. Waldron K. (Ed.) (2007) *Handbook of waste management and co-product recovery in food processing*, CRC Press, ISBN 9780849391323.


## PHM 622 EXPORT ORIENTED HORTICULTURE 1(1+0)

**WHY THIS COURSE?**

This course relates the national economy which is dependent on the contribution of the export-oriented income. Export oriented policies and laws must be followed by the growers to meet the requirement of the importing countries.

**AIM OF THIS COURSE**

To acquaint the students with the export oriented requirements of horticultural crops.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Product specifications and sanitary measures | 1. Introduction |
| | | 2. Produce specifications and standards |
| | | 3. Export oriented sanitary measures |
| 2. | Export related policies | 1. Export implications |
| | | 2. Treatment of solid and liquid waste |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. entry barriers, covering issues such as economies of scale, high capital investments, difficult access to distribution channels and markets, *etc.*
2. bargaining power of buyers, which relates to issues such as the level of concentration of buying power, buyers' access to information, switching opportunities and costs, *etc.*

**THEORY**

**Block 1: Product specifications and sanitary measures**

**UNIT-I:** *Introduction:* India's position and potentiality in world trade; export promotion zones in India. Export and import policy, problem in export of fresh horticultural produce, export infrastructure (sea port, airport, bulk storage facilities, irradiation, Vapour Heat Treatment, quarantine, transportation *etc*,).quarantine need, major export destination and competing nations for selected crops.

**UNIT-II:** *Produce specifications and standards:* Scope, produce specifications, quality and safety standards for export of fruits *viz.*, mango, grape, litchi, pomegranate, walnut, cashewnut *etc.*, vegetables *viz.*, onion, chilli, okra, bitter gourd, gherkin *etc.*, flowers *viz.*, rose, carnation, chrysanthemum, gerbera, specialty flowers *etc.*, cut green and foliage plants.

**UNIT-III:** *Export oriented sanitary measures:* Processed and value-added products, Postharvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; APEDA and its role in export, WTO and its implications, sanitary and phyto-sanitary measures. Codex norms and GAP and SOP for export of major horticultural crops from India.

**Block 2: Export related policies**

**UNIT-I:** *Export implications:* Export of seed and planting material; implications of PBR, treatments of horticultural produce, MRL for export of horticultural produce.

**UNIT-II:** *Export oriented regulatory issues:* Agriculture Export Policy, Export procedure; EXIM Policy, APMC act, Auction Centres, Regulatory issues of Ministry of Commerce, GoI.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Student presentation.

**SUGGESTED READINGS**


1. Bartz, J.A. and Brecht, J.K. (2002) *Postharvest Physiology and Pathology of Vegetables* (IInd Edition) Marcel Dekkar, Inc, New York.
2. Bhattacharjee, SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.
3. Bose, T.K, Maiti, R.G., Dhua, R.S. and Das, P. (1999) *Floriculture and Landscaping*. Naya Prokash.
4. Bose, T.K. and Yadav, L.P. (1989) *Commercial Flowers*. Naya Prokash, Kolkata.
5. Chadha, K.L. (1995) *Advances in Horticulture*. Vol. XII. Malhotra Publ. House.
6. Islam, C.N. (1990) *Horticultural Export of Developing Countries: Past preferences, future prospects and policies.* International Institute of Food Policy Research, USA.
7. Reddy, S., Janakiram, T., Balaji, T., Kulkarni, S. and Misra, R. L. (2007) *Hightech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi.
8. Sheela, V.L. (2007) *Flowers in Trade*. New India Publ. Agency.


## PHM 623 FOOD ADDITIVES 2(1+1)

**WHY THIS COURSE?**

Food additives have been used for centuries to improve and preserve the taste, texture, nutrition and appearance of food. Food additives and preservatives are used in today's food supply to prevent foodborne illness, enable the transportation of food to areas that otherwise wouldn't be possible, and for the efficient manufacture of products to consistently meet the established quality standards. Although there may be certain ill effects of additives and preservatives in food, they increase its shelf life and help retain the flavour, colour, and texture. They also help maintain or increase the nutritive value of food. Hence this customized course.

**AIM OF THIS COURSE**

To understand the chemistry of food additives and their functions in food processing

This course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Food Additives | 1. Importance of food additives |
| | | 2. Methods of preservation |
| | | 3. Different additives types |
| | | 4. Flavour technology |
| | | 5. Use of functional ingredients and safety and toxicological evaluation |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to understand:

1. Importance of food additives in processing and preservation of horticultural produce.
2. About Flavour technology.
3. Safety and toxicological evaluation of food additives.

**THEORY**

**Block 1: FOOD ADDITIVES**

**UNIT-I:** Importance of food additives in processing and preservation of horticultural produce by food additives. Food additives-definitions, classification, international numbering systems and functions.

**UNIT-II:** Principles and methods of preservation by use of sugar, salt, spices, essential oils, vinegar, mode of action of chemical preservatives.

**UNIT-III:** Antioxidants, colours and flavours (synthetic and natural), emulsifiers, sequester ants, humectants, hydrocolloids, sweeteners, acidulants, buffering salts, anticaking agents, clarifying agents *etc.* – uses in horticulture foods and functions in formulations.

**UNIT-IV:** Flavour technology: types of flavours, flavour generated during processing – reaction flavours, flavour composites, stability of flavours during food processing, flavour emulsion, essential oils and oleoresins *etc.*

**UNIT-V:** Uses of enzymes in extraction of juices. Pectic substances and their role as jellifying agents. Protein, starches and lipids as functional ingredients, functional properties and applications in horticultural food. Safety and toxicological evaluation of food additives: GRAS-tolerance levels and toxic levels in foods, LD50 value.

**PRACTICAL**

1. Extraction of fruit and vegetable juices using enzymes clarification;
2. Role of additives and preservatives in RTS, cordial, squash, concentrate, syrup, jam, jelly, marmalade, ketchup, sauce, preserves, chutneys, pickles, candies, crystallized products;
3. Estimation of benzoic acid, sulphur-di-oxide;
4. Estimation of pectins.

**TEACHING METHODS/ ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Exposure visits
- Student presentation

**SUGGESTED READINGS**

1. Additives and colours FDA https://www.fda.gov/food/ingredientspackaginglabeling/foodadditivesingredients/ucm094211.htm
2. Branen, A.L., Davidson, P.M., Salminen, S. and Thorngate, IJ.H. (2001) *Food Additives* (2nd Edition), Marcel Dekker Inc., ISBN 0824793439.
3. DGHS Manual 8: *Manual of Methods of Analysis of Foods-Food Additives.*
4. George, A.B. (1996) *Encyclopedia of Food and Color Additives*. Vol. III. CRC Press. https://www.eufic.org/en/whats-in-food/category/additives https://www.faia.org.uk/
5. Madhavi, D.L., Deshpande, S.S. and Salunkhe, D.K. (1996) *Food Antioxidants: Technological, Toxicological and Health Perspective*. Marcel Dekker.
6. Michael and Ash, I. (2008). *Handbook of Food Additives* (3rd Edition), Synapse Information Resources, Inc., ISBN 9781934764008.
7. Nagodawithana, T and Reed, G. (1993) Enzymes in food processing. Academic Press.
8. Ötleş S. (Ed.) (2005) *Methods of Analysis of Food Components and Additives*, CRC Press, ISBN 9780849316470.
9. Taylor, A.J. and Linforth, R.S.T. (2010) *Food Flavour Technology* (2nd Edition), Wiley-Blackwell, ISBN 9781405185431.
10. Wood, R., Foster, L., Damant, A. and Key, P. (2004) *Analytical methods for food additives*, CRC Press, ISBN 084932534X.

## PHM 624 ADVANCES IN PROCESSING OF PLANTATION, SPICE, MEDICINAL AND AROMATIC PLANTS 3(3+0)

**WHY THIS COURSE?**

This course deals with post-harvest operations, processing and value addition details of plantation, spices, medicinal and aromatic plants. This course would be very useful for everyone who so ever is interested to know about harvesting and handling of spices, plantation, medicinal and aromatic plants.

**AIM OF THIS COURSE:**

To familiarize with advances in processing of plantation, spices, medicinal and aromatic plants.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Handling and utilization of plantation, spice, medicinal and | 1. Introduction |
| | | 2. By product utilization |

| | | |
|---|---|---|
| | aromatic plants | 3. Value addition of medicinal and aromatic plants |
| 2. | Essential oil utilization and their storage | 1. Quality analysis |
| | | 2. Treatment of solid and liquid waste |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Learn utilization and processing of spice, plantation, medicinal and aromatic plants.
2. Apply appropriate processing technique to the crop related processing technique.

**THEORY**

**Block 1: Handling and utilization of plantation, spice, medicinal and aromatic plants**

**UNIT-I:** Introduction: Commercial uses of spices and plantation crops. Introduction to processing and products in plantation and spice crops. Significance of on farm processing and quality of finished products. Processing of major spices, extraction of oleoresin and essential oils. Processing of produce from plantation and spice crops.

**UNIT-II:** By product utilization: By product utilization in plantation crops for coir production, mushroom culture, cocopeat, bee keeping, toddy tapping, Oil cake production and utilization, vermi-composting, Fuel wood and timber wood from perennial spices and plantation crops (crops, viz. coconut, areca nut, cashew nut, oil palm, palmyrah, date palm, cocoa, tea, coffee, rubber *etc.* cardamom, black pepper, ginger, turmeric, chilli and paprika, vanilla, cinnamon, clove, nutmeg, allspice, coriander, fenugreek, curry leaf, *etc*).

**UNIT-III:** Value addition of medicinal and aromatic plants: Value addition on aromatic oils and medicinal herbs. Principles and practices of different types of extraction - distillation, solvent extraction, enfleurage, soxhlet, supercritical fluid extraction, phytonics, counter current extraction. Commercial uses of essential oils, aroma therapy. Commercial utilization of spent material.

**Block 2: Essential oil utilization and their storage**

**UNIT-I:** Quality determination of essential oils: Qualitative determination of essential oils. Quality analysis and characterization through chromatographs.

**UNIT-II:** Storage of essential oils: Storage of essential oils. Utilization of spent material of medicinal and aromatic crops in manufacture of agarabatti, organic manures and other useful products. Detoxification of waste materials. Role of spent material in bio-control of diseases and pest in organic farming. Role of micro-organisms in conversion of waste in to useful products.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Student presentation

**SUGGESTED READINGS**

1. Afoakwa E.O. (2016) *Cocoa Production and Processing Technology*, CRC Press, ISBN 9781138033825.
2. Chakraverty, A., Majumdar, A.S., Raghavan, G.S.V. and Ramaswamy H.S. (2003). *Handbook of Postharvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices*, CRC Press, ISBN 9780824705145.
3. Chi-Tang, Ho, Jen-Kun, Lin, Fereidoon Shahidi (2008). *Tea and Tea Products: Chemistry and Health-Promoting Properties*, CRC Press, ISBN 9780849380822. https://www.cabdirect.org/cabdirect/abstract/20006781145: https://www.springerprofessional.de/en/value-addition-in-flowers/4657550
4. Kumar, N., Khader, J.B.M.M., Rangaswami, P., and Irulappan, I (2017). *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants* (2nd Edition), Oxford & IBH Publishers, ISBN 9788120417762.
5. Pruthi J. S. (1993) *Major Spices of India Crop Management Postharvest Technology*, ICAR Publication, ISBN 1234567147556.
6. Siddiqui, M.W. (2015). *Postharvest Biology and Technology of Horticultural Crops: Principles and Practices for Quality Maintenance*, CRC Press, ISBN 9781771880862.

## PHM 625 VALUE ADDITION IN ORNAMENTAL CROPS 2(1+1)

**WHY THIS COURSE?**

Ornamental crops provide better income from an area with higher profitability. The production of flower crops has increased significantly and there is huge demand for floricultural products in the world resulting in growing international flower trade. Value addition in floriculture increases the economic value and consumer appeal of any floral commodity. This course will be useful as a source of income generation.

**AIM OF THIS COURSE**

To acquaint the students about the scope and ways of value addition in ornamental crops.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Value addition of flowers | 1. Introduction |
| | | 2. Value addition of flower crops |
| | | 3. Neutraceuticals from petals |
| 2. | Floral arrangements and women empowerment | 1. Floral arrangements |
| | | 2. Women empowerment |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Will be helpful in converting waste into wonder by making potpourris, greeting cards *etc.*
2. Students can give training to women and create a source of employment to rural women.

**THEORY**

**Block 1: Value addition of flowers**

**UNIT-I:** *Introduction:* Importance, opportunities and prospects of value addition in floriculture; national and global scenario; production and exports, supply chain management.

**UNIT-II:** *Value addition of flower crops:* Dry flower making including pot pourries, their uses and trade; extraction technology, uses, sources and trade in essential oils; aroma therapy; pigment and natural dyes extraction technology, sources, uses and trade.

**UNIT-III:** *Neutraceuticals from petals:* Pharmaceutical and neutraceutical compounds from flower crops; petal embedded handmade paper making and uses, preparation of products like gulkand, rose water, gulroghan, attar, and pankhuri.

**Block 2: Floral arrangements and women empowerment**

**UNIT-I:** *Floral arrangements:* Floral craft including bouquets, garlands, flower arrangements, *etc.* tinting (artificial colouring) of flower crops;

**UNIT-II:** *Women empowerment:* Women empowerment through value added products making.

**PRACTICAL**

1. Dry flower making including pot pourries; extraction technology, uses, sources and trade in essential oils;
2. Pigment and natural dyes extraction technology;
3. Pharmaceutical and neutraceutical compounds from flower crops;
4. Preparation of products like gulkand, rose watergulroghanattar, pankhuri:
5. Petal embedded handmade paper making;
6. Floral craft including bouquets, garlands, flower arrangements *etc.*;
7. Tinting (artificial colouring) of flower crops.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Student presentation
- Group Work/ Seminars
- Product preparation and income generation assessment

**SUGGESTED READINGS**


1. Bhattacharjee, S.K. and De, L.C. (2004) *Advances in Ornamental Horticulture* Vol. V, Pointer publishers, Jaipur.
2. Gary L. McDaniel. (1989) *Floral design and arrangement*. A Reston Book. Prentice hall. New Jersey.
3. http://www.vedamsbooks.com/no103218/user_forgot_pass.php
4. https://www.springerprofessional.de/en/value-addition-in-flowers/4657550
5. Lauria, A. and Victor, H.R. (2001) *Floriculture – Fundamentals and Practices*. Agrobios.
6. Lesniewicz, Paul. (1994) *Bonsai in your home*. Sterling publishing Co, New York.
7. Prasad, S. and Kumar, U. (2003) *Commercial Floriculture*. Agrobios.
8. Randhawa, G.S. and A. Mukhopadhyay, (2000) *Floriculture in India*, Allied publishers, India.
9. Reddy, S., Janakiram, T., Balaji, T., Kulkarni, S. and Misra, R.L. (2007). *Hightech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi.
10. Salunkhe, K., Bhatt, N.R. and Desai, B.B. (2004) *Postharvest biotechnology of flowers and ornamental plants*. Naya Prokash, Kolkata.

# DEPARTMENT OF PLANT PATHOLOGY
# AGRICULTURE UNIVERSITY, JODHPUR

### Semester Wise Course Title and Credits: M.Sc. (Agri.) Plant Pathology

| S. No. | Course No. | Course Title | Credit hrs. |
|---|---|---|---|
| | | **Semester-I** | |
| 1. | PPATH 511* | Mycology | 3(2+1) |
| 2. | PPATH 512* | Principles of Plant Pathology | 3(2+1) |
| 3. | PPATH 513* | Plant Virology | 3(2+1) |
| 4. | PPATH 514# | Post-Harvest Diseases | 3(2+1) |
| 5. | PPATH 515# | Ecology of Soil-Borne Plant Pathogens | 2(1+1) |
| 6. | PPATH 516# | Plant Quarantine and Regulatory Measures | 1(1+0) |
| | | **Semester-II** | |
| 7. | PPATH 521* | Plant Pathogenic Prokaryotes | 3(2+1) |
| 8. | PPATH 522** | Diseases of Field and Medicinal Crops | 3(2+1) |
| 9. | PPATH 523# | Principles of Plant Disease Management | 3(2+1) |
| 10. | PPATH 524# | Plant Nematology | 3(2+1) |
| 11. | PPATH 525# | Diseases of Vegetable and Spices Crops | 3(2+1) |
| 12. | PPATH 526# | Detection and Management of Seed Borne Pathogens | 3(2+1) |
| 13. | PPATH 527# | Biological Control of Plant Diseases | 2(1+1) |
| | | **Semester-III** | |
| 14. | PPATH 531** | Techniques In Detection and Diagnosis of Plant Diseases | 2(0+2) |
| 15. | PPATH 532** | Chemicals and Botanicals in Plant Disease Management | 3(2+1) |
| 16. | PPATH 533# | Integrated Disease Management | 3(2+1) |
| 17. | PPATH 534# | Diseases of Fruits, Plantation and Ornamental Crops | 3(2+1) |
| 18. | PPATH 535# | Epidemiology and Forecasting of Plant Diseases | 1(1+0) |
| 19. | PPATH 536# | Disease Resistance in Plants | 2(2+0) |
| 20. | PPATH 591 | Master's Seminar | 01 |
| | | **Semester-VI** | |
| 21. | PPATH 598 | Comprehensive | NC |
| 22. | PPATH 599 | Master's Research | 30 |
| | Minor Courses | | 8 |
| | Supporting Courses | | 6 |
| | Common Non-Credit Courses | | 5 NC |

*Core Courses- External Examination, ** Compulsory courses- Internal Examination, #Optional courses, NC-Non-credit (Satisfactory remark is required)

Note: No. of credit hours/courses may be increased as per the choice of courses suggested by Advisory Committee of the students.

### Course Requirement - M.Sc. (Agri.) Plant Pathology

| | |
|---|---|
| Core courses | PPATH 511, PPATH 512, PPATH 513, PPATH 521 |
| Compulsory courses | PPATH 522, PPATH 531, PPATH 532 |
| Optional courses | PPATH 514, PPATH 515, PPATH 516, PPATH 523, PPATH 524, PPATH 525, PPATH 526, PPATH 527, PPATH 533, PPATH 534, PPATH 535, PPATH 536 |
| Minor courses | MBB 511, MBB 523, MBB 531, ENTO 523, ENTO 524, ENTO 531, ENTO 532, NEMA 506, NEMA 510 or any other as per the requirement of the research programme or advised by the advisory committee. |
| Supporting courses* | STAT 512, STAT 521, STAT 523 |
| Non-credit compulsory Courses | PGS 501, PGS 502, PGS 503, PGS 504 and PGS 505 |
| Seminar | PPATH 591 |
| Comprehensive | PPATH 598 |
| Thesis/Research | PPATH 599 |

| | |
|---|---|
| Deficiency courses | As deemed suitable by advisory committee |

*Suggested by advisory committee and the above courses shall be offered as per schedule of the concerned Departments.

**Semester Wise Breakup: M.Sc. (Ag.) Plant Pathology**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Common compulsory Course (Non- Credit) | Seminar |
|---|---|---|---|---|---|
| I | 3 (9) | 1 (3) | 1 (3) | 3 (3) | -- |
| II | 2 (6) | 1 (3/2) | 1 (3) | 2 (2) | -- |
| III | 2 (5) | 1 (3/2) | -- | -- | 1 |
| IV | -- | -- | -- | -- | -- |

**Semester Wise Course Title and Credits: Ph.D. Plant Pathology**

| S. No | Course No. | Course Titles | Credit hours |
|---|---|---|---|
| | | **Semester-I** | |
| 1. | PPATH 611* | Advances in Plant Virology | 3(2+1) |
| 2. | PPATH 612* | Advances in Plant Pathogenic Prokaryotes | 3(2+1) |
| 3. | PPATH 613# | Principles and Procedures of Certification | 1(1+0) |
| 4. | PPATH 691 | Doctoral Seminar - I | 1(1+0) |
| | | **Semester-II** | |
| 5. | PPATH 621** | Advances in Mycology | 3(2+1) |
| 6. | PPATH 622** | Molecular Basis of Host-Pathogen Interaction | 3(2+1) |
| 7. | PPATH 623# | Plant Biosecurity and Biosafety | 2(2+0) |
| 8. | PPATH 692 | Doctoral Seminar - II | 1(1+0) |
| | | **Semester-III & Onward Semesters** | |
| 9. | PPATH 698 | Preliminary (Written +Oral) | NC |
| 10. | PPATH 699 | Doctoral Research | 75(0+75) |

**Core Courses- External Examination, ** Compulsory courses- Internal Examination #Optional courses, NC-Non credit (Satisfactory remark is required)*

**Note:** No. of credit hours/courses may be increased as per the choice of courses suggested by Advisory Committee of the students.

**Course Requirement for Ph.D. Plant Pathology**

| | |
|---|---|
| Core courses | PPATH 611, PPATH 612 |
| Compulsory courses | PPATH 621, PPATH 622 |
| Optional courses | PPATH 613, PPATH 623 |
| Minor courses | MBB 511, MBB 523, MBB 531, ENTO 522, ENTO 523, ENTO 524, ENTO 531, ENTO 532, ENTO 538, NEMA 506, NEMA 509, NEMA 510, NEMA 524 or any other as per the requirement of the research programme or advised by the advisory committee. |
| Supporting courses* | STAT 512, STAT 513, STAT 521, STAT 523 |
| Non-credit compulsory courses | PGS courses$ |
| Seminar | PPATH 691, PPATH 692 |
| Comprehensive | PPATH 698 |
| Thesis/Research | PPATH 699 |
| Deficiency courses | As deemed suitable by advisory committee |

$If not studied during Masters *suggested by advisory committee and *the above courses shall be offered as per schedule of the concerned Department.*

**Semester Wise Breakup (Ph.D. Plant Pathology)**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Common compulsory Course (Non-Credit) | Seminar |
|---|---|---|---|---|---|
| I | 2 (6) | 1 (3) | 1 (3) | - | 1 |
| II | 2 (6) | 1 (3) | 1 (3) | - | 1 |

| | |
|---|---|
| III & Onward | **Research work** |

**Examination Pattern: M.Sc. (Agri.) & Ph.D. Plant Pathology**

| Particulars | Quiz/ Assignment | Mid Term | Final Examination | |
|---|---|---|---|---|
| | | | Theory | Practical |
| Courses with Theory & Practical | 10 | 15 | 50 | 25 |
| Courses Only Theory | 10 | 15 | 75 | |
| Courses Only Practical | 10 | 15 | | 75 |

**Comprehensive Exam Pattern:** Written Exam followed by Oral Exam

(i.) Written Exam:

M.Sc. (Agri.): 2 papers (1 Major + 1 Supporting & Optional subject)

Ph.D.: 3 papers (2 Major + 1 Supporting & Optional subject)

Maximum marks: 100 each

Paper setting: Internal under the Chairmanship of HOD.

Evaluation: Internal under the Chairmanship of HOD.

Qualifying marks:

M.Sc. (Agri.): 60% individually

Ph.D.: 65% individually

(ii.) Oral Exam: 100 marks

M.Sc. (Agri.): After qualifying the Written Examination, the Oral Exam should be conducted by the Students' Advisory Committee in presence of HOD.

Ph.D.: Exam will be conducted by External Examiner

Grading of the Comprehensive Exam (M.Sc. & Ph.D.): Satisfactory/ Not Satisfactory.

# COURSE CONTENTS: M.Sc. (Agri.) PLANT PATHOLOGY

## PPATH 511 MYCOLOGY 3(2+1)

**OBJECTIVE:** To develop a comprehensive understanding of fungal diversity, their classification, and their roles in agriculture, human affairs, and ecology.

**COURSE OUTCOME**: The students will be able to identify key fungal groups, understand their economic and ecological significance, and apply classification and identification techniques to mycological specimens.

**THEORY**

**UNIT-I:** Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs. History of mycology. Importance of culture collection and herbariumof fungi. Somatic characters and reproduction in fungi. Modern concept of nomenclature and classification, Classification of kingdom fungi: Stramenopila and Protists.

**UNIT-II:** The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota. Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.

**UNIT-III:** Kingdom fungi: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota, Zygomycota, Ascomycota; Archiascomycetes, Ascomycetous yeasts, Pyrenomycetes, Plectomycetes, Discomycetes, Loculoascomycetes, Erysiphales and anamorphs of ascomycetous fungi.

**UNIT-IV:** Basidiomycota; general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes. Uridinales and Ustilaginales; variability, host specificity and life cycle pattern in rusts and smuts. Mitosporic fungi; status of asexual fungi, their teliomorphic relationships, Molecular characterization of plant pathogenic fungi.

**PRACTICAL**

Detailed comparative study of different groups of fungi; Collection of cultures and live specimens; Saccardoan classification and classification based on conidiogenesis; Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi; Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and aethalia; Oomycota; somatic and reproductory structures of *Pythium*, *Phytophthora*, downy mildews and *Albugo*; Zygomycetes: Sexual and asexual structures of *Mucor*, *Rhizopus*, General characters of VAM fungi; Ascomycetes; fruiting structures, Erysiphales, and Eurotiales; general identification characters of Pyrenomycetes, Discomycetes, Loculoascomycetes and Laboulbeniomycetes, Basidiomycetes; characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes; characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states, Collection, preservation, culturing and identification of plant parasitic fungi; Application of molecular approaches and techniques for identification of fungal pathogens.

**SUGGESTED READINGS**


1. Ainsworth, G. C., Sparrow, F. K. & Susman, H. S. 1973. The Fungi – An Advanced Treatise. Vol. IV (A & B). *Academic Press,* New York.
2. Alexopoulos, C. J., Mims, C. W. & Blackwell, M. 2000. Introductory Mycology. 5th Ed. John Wiley & Sons,New York.
3. Maheshwari, R. 2016. Fungi: Experimental Methods in Biology 2nd Ed. CRC Press, U S.
4. Mehrotra, R S & Arneja, K. R. 1990. An Introductory Mycology. Wiley Eastern, New Delhi.
5. Sarbhoy, A. K. 2000. Text book of Mycology. ICAR, New Delhi.
6. Singh, R. S. 1982. Plant Pathogens – The Fungi. Oxford & IBH, New Delhi.
7. Webster, J. 1980. Introduction to Fungi. 2nd Ed. Cambridge Univ. Press, Cambridge, New York.

## PPATH 512 PRINCIPLES OF PLANT PATHOLOGY 3(2+1)

**OBJECTIVE:** To provide students with a thorough understanding of the principles, mechanisms, and management strategies associated with plant diseases, focusing on both biotic (e.g., fungi, bacteria, viruses) and abiotic causes.

**COURSE OUTCOME:** The students will be able to understand the complex factors involved in plant disease development, diagnose diseases accurately, and apply modern genetic tools to develop resistant plant varieties and improve disease management practices.

**THEORY**

**UNIT-I:** Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

**UNIT-II:** Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

**UNIT-III:** Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defence strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

**UNIT-IV:** Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

**PRACTICAL**

Basic plant pathological techniques; Isolation, inoculation and purification of plant pathogens and proving Koch's postulates; Techniques to study variability in different plant pathogens; Purification of enzymes, toxins and their bioassay; Estimation of growth regulators, phenols, phytoalexins in resistant and susceptible plants.

**SUGGESTED READINGS**


1. Agrios, G. N. 2005. Plant Pathology. 5th Ed. *Academic Press*, New York.
2. Heitefuss, R. & Williams, P. H. 1976. Physiological Plant Pathology. Springer Verlag, Berlin, New York.
3. Mehrotra, R. S. & Aggarwal, A. 2003. Plant Pathology. 2nd Ed. Oxford & IBH, New Delhi.
4. Singh, R. S. 2017. Introduction to Principles of Plant Pathology. 5th Ed. MedTech, New Delhi.
5. Singh, R. P. 2012. Plant Pathology 2nd Ed. Kalyani Publishers, New Delhi.
6. Singh, D. P. & Singh, A. 2007. Disease and Insect Resistance in Plants. Oxford & IBH, New Delhi.
7. Upadhyay, R. K. & Mukherjee, K. G. 1997. Toxins in Plant Disease Development and Evolving Biotechnology. Oxford & IBH, New Delhi.


## PPATH 513 PLANT VIROLOGY 3(2+1)

**OBJECTIVE:** To acquiant students with a comprehensive understanding of plant viruses, including their characteristics, mechanisms of infection, transmission, and management, as well as their economic significance in agriculture.

**COURSE OUTCOME:** The students will have a solid grasp of plant virus biology, how to detect and diagnose viral infections, and strategies for managing viral diseases in crops to enhance agricultural productivity.

**THEORY**

**UNIT-I:** History and economic significances of plant viruses. General and morphological characters, composition and structure of viruses. Myco-viruses, arbo and baculo viruses, satellite viruses, satellite RNAs, phages, viroids and prions. Origin and evolution of viruses and their nomenclature and classification.

**UNIT-II:** Genome organization, replication in selected groups of plant viruses and their movement in host. Response of the host to virus infection: biochemical, physiological, and symptomatical changes. Transmission of viruses and virus-vector relationship. Isolation and purification of viruses.

**UNIT-III:** Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques. Natural (R-genes) and engineering resistance to plant viruses.

**UNIT-IV:** Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival).Management of diseases caused by plant viruses.

**PRACTICAL**

Study of symptoms caused by plant viruses (followed by field visit); Isolation and biological purification of plant virus cultures; Bioassay of virus cultures on indicator plants and host differentials; Transmission of plant viruses (Mechanical, graft and vector and study of disease development); Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology; Antisera production, Detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR–LAMP, Later flow micro array & PCR based techniques; Exposure to basic bio-informatic tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bioedit tool, Claustal X/W, MEGA Software).

**SUGGESTED READINGS**


1. Bos, L. 1964. Symptoms of Virus Diseases in Plants. Oxford & IBH., New Delhi.
2. Brunt, A. A., Krabtree, K. Dallwitz, M. J., Gibbs, A. J. & Watson, L. 1995. Virus of Plants: Descriptions and Lists from VIDE Database. CABI, Wallington.
3. Gibbs, A. & Harrison, B. 1976. Plant Virology - The Principles. Edward Arnold, London.
4. Hull, R. 2002. Mathew's Plant Virology. 4th Ed. Academic Press, New York.
5. Noordam, D. 1973. Identification of Plant Viruses, Methods and Experiments. Oxford & IBH, New Delhi.
6. Wilson, C, 2014. Applied Plant Virology. CABI Publishing England.


| PPATH 514 | POST HARVEST DISEASES | 3(2+1) |
|---|---|---|

**OBJECTIVE:** To equip students with the knowledge and strategies to minimize post-harvest losses in agricultural products, focusing on both biotic and abiotic factors and their impact on food safety, shelf life, and quality.

**COURSE OUTCOME:** The students will be able to assess and manage post-harvest diseases, apply integrated control methods to improve produce shelf life, and ensure the safety and quality of food products, minimizing both financial losses and health risks.

**THEORY**

UNIT-I: Concept of post-harvest diseases, definitions, importance with reference to management and health, principles of plant disease management as pre-harvest and post-harvest, Types of post-harvest problemsboth by biotic and abiotic factors.

UNIT-II: Role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists.

**UNIT-III:** Integrated approaches in controlling diseases and improving the shelf life of produce using nutritional, bio-control agents and other agents, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for health hazards.

**UNIT-IV:** Study of symptoms, toxicosis of various pathogens, knowledge of Codex Alimentarious for each product and commodity. Physical and biological agents/practices responsible for development/ prevention of post-harvest diseases- traditional and improved practices.

**PRACTICAL**

Isolation, characterization and maintenance of post-harvest pathogens, application of antagonists against pathogens *in vivo* condition; Comparative efficacy of different fungicides and bioagents;

Study of different post-harvest disease symptoms on cereals, pulses, oilseed, commercial crops, vegetables, fruits and flowers; Visit to cold storage.

**SUGGESTED READINGS**

1. Pathak, V. N. 1970. Diseases of Fruit Crops and their Control. IBH Publ., New Delhi.
2. Chaddha, K. L & Pareek, O. P. 1992. Advances in Horticulture Vol. **IV**, Malhotra Publ. House, New Delhi.

## PPATH 515 ECOLOGY OF SOIL BORNE PLANT PATHOGENS 2(1+1)

**OBJECTIVE:** To provide a comprehensive understanding of the soil environment in relation to plant pathogens, and the potential of biological control agents (BCAs) in managing soil-borne diseases.

**COURSE OUTCOME:** The students will be able to understand the environmental and microbial dynamics of the rhizosphere, assess the potential of biocontrol agents for managing soil-borne plant diseases, and apply these techniques as part of sustainable disease management practices in agriculture.

**THEORY**

**UNIT-I:** Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Interaction of microorganisms.

**UNIT-II:** Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis. Conducive and suppressive soils.

**UNIT-II:** Biological control- concepts and potentialities for managing soil borne pathogens. Potential of *Trichoderma* and *Pseudomonas* fluorescent in managing plant diseases.

**PRACTICAL**

Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens; Pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils; suppression of test soil- borne pathogens by antagonistic microorganisms; Isolation and identification of different biocontrol agents; Study of various plant morphological structures associated with resistance, testing the effect of root exudates and extracts on spore germination and growth of plant pathogens; Estimating the phenolicsubstances, total reducing sugars in susceptible and resistant plants; Estimating the rhizosphere and root tissue population of microorganisms (pathogens) in plants.

**SUGGESTED READINGS**

1. Baker, K. F. & Snyder, W. C. 1965. Ecology of Soil-borne Plant Pathogens. John Wiley, New York.
2. Cook, R. J. & Baker, K. F. 1983. The Nature and Practice of Biological Control of Plant Pathogens. APS, St Paul, Minnesota.
3. Garret, S. D. 1970. Pathogenic Root-infecting Fungi. Cambridge Univ. Press, Cambridge, New York.
4. Hillocks, R. J. & Waller, J. M. 1997. Soil-borne Diseases of Tropical Crops. CABI, Wallington.
5. Mondia, J. L and Timper, P. 2016. Interactions of micro fungi and plant parasitic nematodes. In: *Biology of Micro fungi* (De-Wei-Lei Ed.). Springer Publications
6. Parker, C. A. Rivera, A. D., Moore, K. J. & Wong, P. T. N. (Eds). 1983. Ecology and Management of Soil-borne Plant Pathogens. APS, St. Paul, Minnesota.

## PPATH 516 PLANT QUARENTINE AND REGULATIONS 1(1+0)

**OBJECTIVE:** To provide a comprehensive understanding of plant quarantine regulations, pest risk management, and the role of quarantine in protecting agriculture from invasive species, including both domestic and international perspectives.

**COURSE OUTCOME:** The students will have a thorough understanding of plant quarantine systems, pest risk management strategies, and the regulatory frameworks involved in controlling the spread of plant pests and diseases, particularly in the context of global trade and agricultural health.

**THEORY**

**UNIT-I:** Historical development in plant quarantine, Definitions of pest, and transgenics as per Govt. notification; Organizational set up of plant quarantine in India. relative importance; quarantine– domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

**UNIT-II:** Acts related to registration of pesticides and transgenics. History of quarantine legislations, Salient features of PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

**UNIT-III:** Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT andother safer techniques of disinfestation/salvaging of infected material.

**UNIT-IV:** WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures. Visit to plant quarantine station and PEQ facilities.

**SUGGESTED READINGS**

1. Rajeev, K. & Mukherjee, R. C. 1996. Role of Plant Quarantine in IPM. Aditya Books.
2. Rhower, G. G. 1991. Regulatory Plant Pest Management. In: Handbook of Pest Management inAgriculture. 2nd Ed. Vol. **II**. (Ed. David Pimental). CRC Press.

## PPATH 521 PLANT PATHOGENIC PROKARYOTES 3(2+1)

**OBJECTIVE:** To provide a deep understanding of the biology, taxonomy, and pathogenicity of plant-associated prokaryotes (bacteria, phytoplasmas, spiroplasmas), with a focus on their mechanisms of infection, variability, and management strategies for plant diseases caused by these organisms.

**COURSE OUTCOME:** The students will be able to identify and classify plant pathogenic prokaryotes, understand their mechanisms of infection and variability, and apply appropriate strategies for managing bacterial diseases in plants.

**THEORY**

**UNIT-I:** Prokaryotic cell: History and development of Plant bacteriology, history of plant bacteriology in India. Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins. Structure of bacterial cell. Structure and composition of gram negative and gram positive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccaride structure; Membrane transport; fimbrae and pili (Type IV pili); Mechanism of flagellar rotatory motor and locomotion, and bacterial movement; Glycocalyx (S-layer; capsule); the bacterial chromosomes and plasmids; Operon and other structures in cytoplasm; Morphological feature of fastidious bacteria, spiroplasmas and Phytoplasmas.

**UNIT-II:** Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopathogenic prokaryotes.

**UNIT-III:** Taxonomy of phytopathogenic prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma. The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes.

**UNIT-IV:** Variability among phytopathogenic prokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria-conjugation; transformation; transduction); and horizontal gene transfer.

**UNIT-V:** Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle; Classification of phages, Use of phages in plant pathology/bacteriology, Lysogenic conversion; H Plasmids and their types, plasmid borne phenotypes. Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.

**PRACTICAL**

Study of symptoms produced by phytopathogenic prokaryotes; Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria; Stains and staining methods; Biochemical and serological characterization; Isolation of genomic DNA plasmid; Use of antibacterial chemicals/antibiotics; Isolation of fluorescent *Pseudomonas*. Preservation of bacterial cultures; Identification of prokaryotic organisms by using 16S rDNA, and other gene sequences; Diagnosis and management of important diseases caused by bacteria and mollicutes.

**SUGGESTED READINGS**

1. Goto, M. 1990. Fundamentals of Plant Bacteriology. Academic Press, New York.
2. Jayaraman, J. & Verma, J. P. 2002. Fundamentals of Plant Bacteriology. Kalyani Publ., Ludhiana.
3. Mount, M. S. & Lacy, G. H. 1982. Phytopathogenic Prokaryotes. Vols. **I, II** Academic Press, New York.
4. Salle, A. J. 1979. Fundamental Principles of Bacteriology 7th edn.
5 Verma, J. P., Varma, A. & Kumar, D. 1995. Detection of Plant Pathogens and their Management. Angkor Publ., New Delhi.

## PPATH 522 DISEASES OF FIELD AND MEDICINAL CROPS 3(2+1)

**OBJECTIVE:** To equip the students with in-depth knowledge of the diseases affecting major crop groups, focusing on the identification, causes, symptoms, and management strategies for diseases in cereal crops, pulse crops, oilseed crops, cash crops, fodder legume crops, and medicinal crops.

**COURSE OUTCOME:** The students will be able to identify key diseases in a wide variety of crops, understand their causes and symptoms, and apply effective disease management strategies tailored to each crop group to improve agricultural productivity and sustainability.

**THEORY**

**UNIT-I:** Diseases of Cereal crops- Rice, wheat, barley, pearl millet, sorghum and maize**.**

**UNIT-II:** Diseases of Pulse crops- gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea.

**UNIT-III**: Diseases of Oilseed crops- rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.

**UNIT-IV:** Diseases of Cash crops- cotton, sugarcane.

**UNIV-V:** Diseases of Fodder legume crops- berseem, oats, guar, lucerne.

**UNIT-VI:** Medicinal crops- plantago, liquorice, *mulathi,* rosagrass, sacred basil, mentha, *ashwagandha*, *Aloe vera.*

**PRACTICAL**

Detailed study of symptoms and host parasite relationship of important diseases of above mentionedcrops; Collection and dry preservation of diseased specimens of important crops.

**SUGGESTED READINGS**

1. Joshi, L. M, Singh, D. V & Srivastava, K. D. 1984. Problems and Progress of Wheat Pathology in South Asia Malhotra Publ. House, New Delhi.
2. Rangaswami, G. 1999. Diseases of Crop Plants in India. 4th Ed. Prentice Hall of India, New Delhi.
3. Ricanel, C., Egan, B. T., Gillaspie, Jr. A. G. & Hughes, C. G. 1989. Diseases of Sugarcane, Major Diseases. *Academic Press*, New York.
4. Singh, R. S. 2017. Plant Diseases. 10th Ed. Medtech, New Delhi.
5. Singh, U. S., Mukhopadhyay, A. N., Kumar, J. & Chaube, H. S. 1992. Plant Diseases of Internatiobnal Importance. Vol. **I**. Diseases of Cereals and Pulses. Prentice Hall, Englewood Cliffs, New Jersey.

## PPATH 523 PRINCIPLES OF PLANT DISEASE MANAGEMENT 3(2+1)

**OBJECTIVE:** To equip the students with a broad understanding of the various methods for controlling plant diseases, including cultural, physical, biological, chemical, and integrated approaches, as well as molecular techniques for disease resistance.

**COURSE OUTCOME:** The students will be able to design and implement a range of disease management strategies, combining both traditional and modern techniques, to effectively control plant diseases while minimizing environmental impact and ensuring crop safety.

**THEORY**

**UNIT-I:** Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.

**UNIT-II:** History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Label claimof fungicides.

**UNIT-III:** Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants, health *vis-a-vis* environmental hazards, residual effects and safety measures.

**PRACTICAL**

Phytopathometry: Methods of *in vitro* evaluation of chemicals, antibiotics, bio agents against plant pathogens; Field evaluation of chemicals, antibiotics, bio agents against plant pathogens; Soil solarisation, methods of soil fumigation under protected cultivation; Methods of application of chemicals and bio control agents; ED and MIC values, study of structural details of sprayers and dusters; Artificial epiphytotic and screening of resistance.

**SUGGESTED READINGS**


1. Fry, W. E. 1982. Principles of Plant Disease Management. *Academic Press,* New York.
2. Hewitt, H. G. 1998. Fungicides in Crop Protection. CABI, Wallington.
3. Marsh, R. W. 1972. SystemicFungicides. Longman, New York.
4. Nene, Y. L. & Thapliyal, P. N. 1993. Fungicides in Plant Disease Control. Oxford & IBH, New Delhi.
5. Palti, J. 1981. Cultural Practices and Infectious Crop Diseases. Springer Verlag, New York.
6. Vyas, S. C. 1993. Handbook of Systemic Fungicides. Vols. **I-III**. Tata McGraw Hill, New Delhi.


## PPATH 524 PLANT NEMATOLOGY 3(2+1)

**OBJECTIVE:** To provide students with a comprehensive understanding of plant-parasitic nematodes, their biology, ecological interactions, impact on agriculture, and strategies for their management, with a focus on both traditional and emerging nematode-related issues.

**COURSE OUTCOME:** The students will be able to identify nematode-related problems in crops, understand their biology and ecological roles, and apply integrated management strategies to control plant-parasitic nematodes while minimizing their economic impact.

**THEORY**

**UNIT-I:** Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

**UNIT-II:** Gross morphology of plant parasitic nematodes; broad classification, nematode biology,physiology and ecology.

**UNIT-III:** Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasiticnematodes with other organisms.

**UNIT-IV:** Plant nematode relationships, cellular responses to infection by important phytonematodes;physiological specialization among phytonematodes.

**UNIT-V:** Principles and practices of nematode management; integrated nematode management.

**UNIT-VI:** Emerging nematode problems, Importance of nematodes in international trade and quarantine.

**PRACTICAL**

Studies on kinds of nematodes- free-living, animal, insect and plant parasites; nematode extraction from soil; extraction of migratory endoparasites, staining for sedentary endoparasites; examinationof different life stages of important plant parasitic nematodes, their symptoms and histopathology.

**SUGGESTED READINGS**


1. Dropkin, V. H. 1980. An Introduction to Plant Nematology. John Wiley & Sons, New York.
2. Maggenti, A. R. 1981. General Nematology. Springer-Verlog, New York.
3. Perry, R. N. & Moens, M. 2013. Plant Nematology. 2nd Ed. CABI Publishing: Wallingford, UK.
4. Perry, R. N., Moens, M., & Starr, J. L. 2009. Root-knot nematodes, CABI Publishing: Wallingford, UK.
5. Sikora, R. A., Coyne, D., Hallman, J. and Timper, P., 2018. Plant Parasitic Nematodes in Subtropical andTropical Agriculture. 3rd edn. CABI Publishing, England.
6. Thorne, G. 1961. Principles of Nematology. McGraw Hill, New Delhi.
7. Walia, R. K. & Bajaj, H. K. 2003. Text Book on Introductory Plant Nematology. ICAR, New Delhi.
8. Walia, R. K. & Khan, M. R. 2018. A Compendium of Nematode Diseases of Crop Plants, ICAR- AICRP (Nematodes), IARI, New Delhi.


## PPATH 525 DISEASES OF VEGETABLE AND SPICES CROPS 3(2+1)

**OBJECTIVE:** To provide a comprehensive knowledge on the nature, symptoms, epidemiology, and management of diseases affecting a wide range of vegetable and spice crops, including protected cultivation systems and the application of biotechnological approaches for disease resistance.

**COURSE OUTCOME:** The students will be able to identify common diseases in both vegetable and spice crops, understand their epidemiology, and implement effective disease management strategies. They will also be able to apply biotechnological tools to develop resistant crop varieties for sustainable agricultural production.

**THEORY**

**UNIT-I:** Nature, prevalence, factors affecting disease development of tuber, bulb, leafy vegetable, crucifers, cucurbits and solanaceaous vegetables. Diseases of crops under protected cultivation.

**UNIT-II:** Symptoms and management of diseases of different root, tuber, bulb, leafy vegetables, crucifers,cucurbits and solanaceaous vegetable crops.

**UNIT-III:** Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, nutmeg, saffron, cumin, coriander, turmeric, fennel, fenugreek and ginger. Biotechnological approachesin developing disease resistant transgenics.

**PRACTICAL**

Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spicecrops.

**SUGGESTED READINGS**


1. Chaube, H. S., Singh, U. S., Mukhopadhyay, A. N. & Kumar, J. 1992. Plant Diseases of International Importance. Vol. II. Diseases of Vegetable and Oilseed Crops. Prentice Hall, Englewood Cliffs, New Jersey.
2. Gupta, V. K. & Paul, Y. S. 2001. Diseases of Vegetable Crops. Kalyani Publ., New Delhi.
3. Sherf, A. F. & Mcnab, A. A. 1986. Vegetable Diseases and their Control. Wiley Inter Science, Columbia.
4. Singh, R. S. 1999. Diseases of Vegetable Crops. Oxford & IBH, New Delhi.
5. Gupta, S. K. & Thind, T. S. 2006. Disease Problem in Vegetable Production. Scientific Publ., Jodhpur.

6. Walker, J. C. 1952. Diseases of Vegetable Crops. McGraw-Hill, New York.

## PPATH 526 DETECTION AND MANAGEMENT OF SEED BORNE PATHOGENS 3(2+1)

**OBJECTIVE:** To provide a comprehensive understanding of seed pathology, focusing on its economic importance, disease management, seed health, and the impact of pathogens on seed quality.

**COURSE OUTCOME:** The students will be able to assess seed health, identify seed-borne diseases, and implement strategies for producing healthy seeds, thus contributing to improved agricultural productivity and plant health.

**THEORY**

**UNIT-I:** History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

**UNIT-II:** Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

**UNIT-III:** Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed- borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.

**UNIT-IV:** Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogens/ diseases and procedure for healthy seed production. Seed health testing, methods for detecting microorganism.

**PRACTICAL**

Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses; Relationship between seed-borne infection and expression of the disease in the field.

**SUGGESTED READINGS**

1. Agarwal, V. K. & Sinclair, J. B. 1993. Principles of Seed Pathology. Vols. **I** & **II**, CBS Publ., New Delhi.
2. Hutchins, J. D. & Reeves, J. E. (Eds.). 1997. Seed Health Testing: Progress Towards the 21st Century. CABI, Wallington.
3. Paul N. 1988. Seed Pathology. McMillan, London.
4. Suryanarayana, D. 1978. Seed Pathology. Vikash Publ., New Delhi.

## PPATH 527 BIOLOGICAL CONTROL OF PLANT DISEASES 2(1+1)

**OBJECTIVE:** To understand the principles, mechanisms, and applications of biological control in plant disease management, including the use of bio-agents, the factors influencing their effectiveness, and their role in integrated pest management (IPM) and organic farming.

**COURSE OUTCOME:** The students will be able to evaluate and apply biological control strategies for managing plant pathogens, assess the compatibility of bio-agents with different farming practices, and understand the commercialization process of biological control agents for sustainable agricultural practices.

**THEORY**

**UNIT-I:** Concept of biological control, definitions, importance, principles of plant disease management with bio-agents, history of biological control, merits and demerits of biological control.

**UNIT-II:** Types of biological interactions, competition: mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.

**UNIT-III:** Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, bio-control agents, comparative approaches to biological control of plant pathogensby resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of bioagents with agrochemicals and other antagonistic microbes.

**UNIT-IV:** Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, bio-pesticides available in market. Quality control system of bio-control agents.

**PRACTICAL**

Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen *in vitro* and *in vivo* conditions; Preparation of different formulations of selected bioagents and their mass production; Quality parameters of bio-controlagents; One week exposure visit to commercial bio-control agents production unit.

**SUGGESTED READINGS**


1. Campbell, R. 1989. Biological Control of Microbial Plant Pathogens. Cambridge Univ. Press, Cambridge.
2. Cook, R. J. & Baker, K. F. 1983. Nature and Practice of Biological Control of Plant Pathogens. APS, St.Paul, Minnesota.
3. Fokkemma, M. J. 1986. Microbiology of the Phyllosphere. Cambridge Univ. Press, Cambridge.
4. Gnanamanickam, S. S. (Eds). 2002. Biological Control of Crop Diseases. CRC Press, Florida.
5. Heikki, M. T. & Hokkanen, J. M. (Eds.). 1996. Biological Control - Benefits and Risks. CambridgeUniv. Press, Cambridge.
6. Mukerji, K. G., Tewari, J. P., Arora, D. K. & Saxena, G. 1992. Recent Developments in Biocontrol of Plant Diseases. Aditya Books, New Delhi.


## PPATH 531 TECHNIQUES IN DETECTION AND DIAGNOSIS OF PLANT DISEASES 2(0+2)

**OBJECTIVE:** To explore various diagnostic techniques used for the detection and identification of plant pathogens, ranging from traditional methods (visual symptoms, biochemical tests, and cultural studies) to advanced molecular techniques (such as PCR-based methods, next-generation sequencing, and biosensors).

**COURSE OUTCOME:** The outcome is to enhance the accuracy and efficiency of diagnosing plant pathogens, enabling better disease management strategies, improving crop protection, and aiding in the development of resistant plant varieties by leveraging both phenotypic and genotypic diagnostic tools.

**PRACTICAL**

Detection of plant pathogens 1. based on visual symptoms, 2. Biochemical test 3. Using microscopic techniques, 4. Cultural studies; (use of selective media to isolate pathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serological assays 7. Nucleic acid based techniques (Non-PCR– LAMP, Later flow microarray & PCR based- multiplex, nested, qPCR, immune capture PCR, *etc.*); Phenotypic and genotypic tests for identification of plant pathogens; Molecular identification (16S rDNA and 16s-23S rDNA intergenic spacer region sequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing; Volatile compounds profiling by using GC-MS and LC-MS. FAME analysis, Fluorescence in-situ Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors for detection of plant pathogens; Genotypic tools such as genome/specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

**SUGGESTED READINGS**


1. Baudoin, A. B. A. M., Hooper, G. R., Mathre, D. E. & Carroll, R. B. 1990. Laboratory Exercises in Plant Pathology: An Instructional Kit. Scientific Publ., Jodhpur.
2. Chakravarti, B. P. 2005. Methods of Bacterial Plant Pathology. Agrotech,Udaipur.
3. Dhingra, O. D. & Sinclair, J. B. 1986. Basic Plant Pathology Methods. C R C Press, London, Tokyo.
4. Fox, R. T. V. 1993. Principles of Diagnostic Techniques in Plant Pathology, CABI Wallington.
5. Mathews, R. E. F. 1993. Diagnosis of Plant Virus Diseases. CRC Press, Boca Raton, Tokyo.
6. Pathak, V. N. 1984. Laboratory Manual of Plant Pathology. Oxford & IBH, New Delhi.
7. Forster, D. & Taylor, S. C. 1998. Plant Virology Protocols*:* From Virus Isolation to Transgenic Resistance. Methods in Molecular Biology. Humana Press, Totowa, New Jersey.
8. Matthews, R. E. F. 1993. Diagnosis of Plant Virus Diseases. CRC Press, Florida.
9. Noordam, D. 1973. Identification of Plant Viruses, Methods and Experiments. Cent. Agic. Pub. Doc.Wageningen.
10. Trigiano, R. N., Windham, M. T. & Windham, A. S. 2004. Plant Pathology-Concepts and Laboratory Exercises. CRC Press, Florida.


## PPATH 532 CHEMICALS AND BOTANICALS IN PLANT DISEASE MANAGEMENT 3(2+1)

**OBJECTIVE:** To provide a comprehensive understanding of chemicals and botanicals used in plant disease management, covering their classification, modes of action, efficacy, and the various issues related to their use, including environmental and health impacts.

**COURSE OUTCOME:** The students will equip with the knowledge necessary to select, apply, and manage chemicals and botanicals effectively in plant disease control, while understanding their environmental implications, safety precautions, and the development of resistance in plant pathogens. This will help in promoting sustainable and safe plant protection practices.

**THEORY**

**UNIT-I:** History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals and botanicals.

**UNIT-II:** Classification of chemicals used in plant disease management and their characteristics.

**UNIT-III:** Chemicals in plant disease control, *viz.,* fungicides, bactericides, nematicides, antiviral chemicals and botanicals. Issues related to label claim.

**UNIT-IV:** Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

**UNIT-V:** Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides. New generation fungicides and composite formulations of pesticides.

**UNIT-VI:** Efficacy of different botanicals used and their mode of action. Important botanicals used against diseases. General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

**PRACTICAL**

Acquaintance with formulation of different fungicides and plant protection appliances; Formulation of fungicides, bactericides and nematicides; *in vitro* evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides against pathogens; persistence, compatibility with other agro-chemicals; detection of naturally occurring fungicide resistant mutants of pathogen; methods of application of chemicals.

**SUGGESTED READINGS**


1. Bindra, O. S. & Singh, H. 1977. Pesticides - And Application Equipment. Oxford & IBH, New Delhi.
2. Nene, Y. L. & Thapliyal, P. N. 1993. Fungicides in Plant Disease Control. 3rd edn. Oxford & IBH, New Delhi.

3. Torgeson, D. C. (Ed.). 1969. Fungicides. Vol. **II**. An Advanced Treatise. Academic Press, New York.
4. Vyas, S. C. 1993. Handbook of Systemic Fungicides. Vols. **I-III**. Tata McGraw Hill, New Delhi.

## PPATH 533 INTEGRATED DISEASE MANAGEMENT 3(2+1)

**OBJECTIVE:** To provide a thorough understanding of Integrated Disease Management (IDM), including its principles, components, and application to various crops, with a focus on combining biological, chemical, and cultural methods for effective disease control.

**COURSE OUTCOME:** The students will be able to design and implement Integrated Disease Management strategies tailored to different crops, leading to sustainable disease control, reduced dependency on chemicals, and improved crop health.

**THEORY**

**UNIT-I:** Introduction, definition, concept and tools of disease management, components of integrated diseasemanagement- their limitations and implications.

**UNIT-II:** Development of IDM-basic principles, biological, chemical and cultural disease management.

**UNIT-III:** IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed and mustard, pearl millet,pulses, vegetable crops, fruit, plantation and spice crops.

**PRACTICAL**

Application of physical, biological and cultural methods, Use of chemical and biocontrol agents, their compatibility and integration in IDM; Demonstration of IDM and multiple disease management in crops of regional importance as project work.

**SUGGESTED READINGS**

1. Gupta, V. K. & Sharma, R. C. (Eds). 1995. Integrated Disease Management and Plant Health. ScientificPubl., Jodhpur.
2. Mayee, C. D., Manoharachary, C., Tilak, K. V. B. R., Mukadam, D. S. & Deshpande, J. (Eds.). 2004. Biotechnological Approaches for the Integrated Management of Crop Diseases. Daya Publ. House, New Delhi.
3. Sharma, R. C. & Sharma, J. N. (Eds). 1995. Integrated Plant Disease Management. Scientific Publ. Jodhpur.

## PPATH 534 DISEASES OF FRUITS, PLANTATION AND ORNAMENTAL CROPS 3(2+1)

**OBJECTIVE:** To provide a detailed understanding of the symptoms, etiology, and management of diseases affecting a wide range of fruit, plantation, and ornamental crops, along with factors influencing disease development.

**COURSE OUTCOME:** The students will be able to equip with the knowledge to diagnose, manage, and control diseases in fruit, plantation, and ornamental crops, improving crop health, yield, and quality through effective disease management strategies.

**THEORY**

**UNIT-I:** Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm custard apple and their management.

**UNIT-II:** Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconutand their management.

**UNIT-III:** Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, gerbera orchids, marigold, chrysanthemum and their management.

**PRACTICAL**

Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops; Collection and dry preservation of diseased specimens of important crops.

**SUGGESTED READINGS**

1. Gupta, V. K. & Sharma, S. K. 2000. Diseases of Fruit Crops. Kalyani Publ., New Delhi.
2. Pathak, V. N. 1980. Diseases of Fruit Crops. Oxford & IBH, New Delhi.
3. Singh, R. S. 2000. Diseases of Fruit Crops. Oxford & IBH, New Delhi.
4. Walker, J. C. 2004. Diseases of Vegetable Crops. TTPP, India.

## PPATH 535 EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES 1(1+0)

**OBJECTIVE:** To provide a comprehensive understanding of the epidemiology of plant diseases, including the concepts, models, genetic factors, and forecasting techniques used to predict disease outbreaks and manage epidemics effectively.

**COURSE OUTCOME:** The students will be enable to apply genetic and physiological principles of disease resistance in plant breeding and crop management, leading to the development of resistant plant varieties and effective disease control strategies.

**THEORY**

**UNIT-I:** Epidemic concepts, simple interest and compound interest disease, historical development. Elements of epidemics and their interaction. Structures and patterns of epidemics. Modeling, system approaches and expert systems in plant pathology.

**UNIT-II:** Genetics of epidemics. Models for development of plant disease epidemics. Common and natural logarithms, function fitting, area under disease progress curve and correction factors, inoculum dynamics. Population biology of pathogens, temporal and spatial variability in plant pathogens.

**UNIT-III:** Epidemiological basis of disease management. Survey, surveillance and vigilance. Remote sensingtechniques and image analysis. Crop loss assessment.

**UNIT-IV:** Principles and pre-requisites of forecasting, systems and factors affecting various components offorecasting, some early forecasting and procedures based on weather and inoculum potential, modelingdisease growth and disease prediction. Salient features of important forecasting models.

**SUGGESTED READINGS**

1. Campbell, C. L. & Madden, L. V. 1990. Introduction to Plant Disease Epidemiology. John Wiley & Sons, New York
2. Cooke, B., Jones, D. M. and Gereth, K. B. 2018 The Epidemiology of Plant Diseases. Springer Publications.
3. Cowling, E. B. & Horsefall, J. G. 1978. Plant Disease. Vol. **II**. Academic Press, New York.
4. Laurence, V. M., Gareth, H. & Frame Van den Bosch (Eds.). The Study of Plant Disease Epidemics. APS, St. Paul, Minnesota.
5. Nagarajan, S. & Murlidharan, K. 1995. Dynamics of Plant Diseases. Allied Publ., New Delhi.
6. Thresh, J. M. 2006. Plant Virus Epidemiology. Advances in Virus Research 67, *Academic Press*, New York.
7. Van der Plank, J. E. 1963. Plant Diseases Epidemics and Control. *Academic Press,* New York.
8. Zadoks, J. C. & Schein, R. D. 1979. Epidemiology and Plant Disease Management. Oxford Univ. Press, London.

## PPATH 536 DISEASE RESISTANCE IN PLANTS 2(2+0)

**OBJECTIVE:** To provide an in-depth understanding of the genetics and mechanisms of disease resistance in plants, including the dynamics of pathogenicity, host defense systems, and strategies for managing resistance genes.

**COURSE OUTCOME:** The students will be able to equip with the ability to apply epidemiological principles and forecasting models in plant pathology, enabling better disease management, accurate prediction of epidemics, and minimizing crop losses through timely interventions.

**THEORY**

**UNIT-I:** Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminologies. Disease escape non-host resistance and disease tolerance.

**UNIT-II:** Genetic basis of disease resistance, types of resistance, identification of physiological races of pathogen, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

**UNIT-III:** Host defence system, morphological and anatomical resistance, pre-formed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms. Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

**SUGGESTED READINGS**


1. Deverall, B. J. 1977. Defence Mechanisms in Plants. Cambridge Univ. Press, Cambridge, New York.
2. Mills, D. *et al.*1996. Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction. APS, St Paul, Minnesota.
3. Parker, J. 2008. Molecular Aspects of Plant Diseases Resistance. Blackwell Publ.
4. Robinson, R. A. 1976. Plant Pathosystems. Springer Verlag, New York.
5. Singh, B. D. 2005. Plant Breeding – Principles and Methods. 7th Ed. Kalyani Publ., Ludhiana
6. Van der Plank, J. E. 1975. Principles of Plant Infection. Academic Press, New York.
7. Van der Plank, J. E. 1978. Genetic and Molecular Basis of Plant Pathogenesis. Springer Verlag. New York.
8. Van der Plank, J. E. 1982. Host Pathogen Interactions in Plant Disease. Academic Press, New York.
9. Van der Plank, J. E. 1984. Disease Resistance in Plants. Academic Press, New York.

# COURSE CONTENTS: Ph.D. PLANT PATHOLOGY

## PPATH 611 ADVANCES IN PLANT VIROLOGY 3(2+1)

**OBJECTIVE:** To provide an in-depth understanding of plant virus biology, including virus structure, replication, evolution, vector relationships, and the use of molecular techniques for virus detection, as well as strategies for virus resistance and genetic engineering in plants.

**COURSE OUTCOME:** The students will be enable to diagnose and manage plant virus resistance through advanced molecular tools, improve virus detection methods, and apply genetic engineering techniques to develop virus-resistant plants for enhanced crop protection.

**THEORY**

**UNIT-I:** Origin, evolution and interrelationship with animal viruses. Virus morphology, structure, architecture, replication (overview of host and viral components required), assembly and virus specific cytological effects in infected plant cells. Mechanisms leading to the evolution of new viruses/strains: mutation, recombination, pseudo-recombination, component re-assortment *etc.*

**UNIT-II:** Major vector groups of plant viruses and their taxonomy, virus-vector relationship, molecular mechanism of virus transmission by vectors. Terminologies used in immunology and serology. Classification, structure and functions of various domains of Immunoglobulins. Production of Polyclonal and monoclonal antibodies for detection of viruses. Immuno/serological assays (Slide agglutination tests, Test tube precipitation test, Double agar diffusion test, ELISA (DAC, DAS, TAS), Dot Immuno Binding Assay, and nucleic acid based assays for detection of plant viruses.

**UNIT-III:** Polymerase Chain Reaction based (PCR, reverse transcriptase PCR, multiplex PCR, Nested PCR, Real time/q PCR) and non PCR based: LAMP, Fluorescent *in situ* hybridization (FISH), dot blot hybridization. Plant virus genome organization (General properties of plant viral genome-information content, coding and non-coding regions), replication, transcription and translational strategies of pararetroviruses, geminiviruses, tobamo-, poty-, bromo, cucumo, ilar, tospoviruses, satellite viruses andsatellite RNA.

**UNIT-IV:** Gene expression, regulation and viral promoters. Genetic engineering with plant viruses, viral suppressors, RNAi dynamics and resistant genes. Virus potential as vectors, genetically engineered resistance, transgenic plants. Techniques and application of tissue culture for production of virus free planting materials. Phylogenetic grouping system based on partial/complete sequences of virus genomes and using of next generation sequencing technology in plant virus discovery.

**PRACTICAL**

Purification of viruses, SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation; Acquaintance with different serological techniques (i) DAC- ELISA (ii) DAS-ELISA (iii) DIBA (iv) Western blots (v) (ab) 2-ELISA. Nucleic acid isolation, DOT-blot, southern hybridization, probe preparation, and autoradiography; PCR application and viral genome cloning of PCR products, plasmid purification, enzyme digestion, sequencing, annotation of genes, analysis of viral sequences (use of gene bank, blast of viral sequences and phylogeny). Bioinformatics analysis tools for virology (ORF finder, Gene mark, Gene ontology, BLAST, Clustal X/W, Tm pred and Phylogeny programs).

**SUGGESTED READINGS**


1. Davies. 1997. Molecular Plant Virology: Replication and Gene Expression. CRC Press, Florida.
2. Fauquet., *et al.* 2005. Vius Taxonomy. VIII Report of ICTV. *Academic Press*, New York.
3. Gibbs, A. & Harrison, B. 1976. Plant Virology - The Principles. Edward Arnold, London.
4. Jones, P., Jones, P. G. & Sutton, J. M. 1997. Plant Molecular Biology: Essential Techniques. John Wiley & Sons, New York.
5. Khan, J. A. & Dijkstra. 2002. Plant Viruses as Molecular Pathogens. Howarth Press, New York.
6. Maramorosch, K., Murphy, F. A. & Shatkin, A. J. 1996. Advances in Virus Research. Vol. **46**. Academic Press, New York.

7. Pirone, T. P. & Shaw, J. G. 1990. Viral Genes and Plant Pathogenesis. Springer Verlag, New York.
8. Roger Hull. 2002. Mathew's Plant Virology (4th Ed.). Academic Press, New York.
9. Thresh, J. M. 2006. Advances in Virus Research Academic Press, New York.

## PPATH 612 ADVANCES IN PLANT PATHOGENIC PROKARYOTES 3(2+1)

**OBJECTIVE:** To provide a detailed understanding of the biology, genetics, taxonomy, and pathogenicity of prokaryotes, focusing on their role in plant diseases, methods for identifying phytopathogenic bacteria, and strategies for managing bacterial diseases.

**COURSE OUTCOME:** The students will be enable to to equip with the knowledge to identify, understand, and manage bacterial plant pathogens, using advanced techniques like genetic engineering, CRISPR, and RNA silencing to control bacterial diseases and enhance plant health.

**THEORY**

**UNIT-I:** Prokaryotic cell: Molecular basis for origin and evolution of prokaryotic life, RNA world, prokaryotic cytoskeletal proteins. Flagella structure, assembly and regulation. Structure and composition (bacteria) cell wall/envelop, Types of secretion systems (TI to TIV) and their molecular interaction, fimbriae and pili (Type IV pili), Bacterial chromosomes and plasmids, other cell organelles. Growth, nutrition and metabolism in prokaryotes (Embden Meyerhof pathway, Phosphoketolase Pathway and Entner Doudoroff Pathway).

**UNIT-II:** Current trends in taxonomy and identification of phytopathogenic prokarya: International code of nomenclature, Polyphasic approach, New / special detection methods for identification of bacterialplant pathogens. Taxonomic ranks hierarchy; Identification, Advances in classification and Nomenclature.

**UNIT-III:** Bacterial genetics: General mechanism of variability (mutation), specialized mechanisms of variability. Transposable genetic elements in bacteria-integron and prophages, Mechanism of gene transfer. Pathogenicity islands, horizontal gene transfer, Bacterial Pan-Genome.

**UNIT-IV:** Bacteriophages: Composition, structure and infection. Classification and use of phages in plant pathology/bacteriology. Host pathogen interactions: Molecular mechanism of pathogenesis: Pathogenicity factors of soft rot, necrosis, wilt, canker *etc*. Immunization, induced resistance/ Systemic Acquired Resistance, Quorum sensing. Bacterial pathogenicity and virulence: Molecular mechanism of virulence and pathogenesis, bacterial secretion systems, pathogenicity of bacterial enzymes that degrade the cell walls, Role of hrp/hrc genes and TALE effectors. Synthesis and regulation of EPSs.

**UNIT-V:** Beneficial Prokaryotes-Endophytes, PGPR, Phylloplane bacteria and their role in disease management. Endosymbionts for host defence. Advances in management of diseases caused by prokaryotes: genetic engineering, RNA silencing; CRISPR cas9.

**PRACTICAL**

Pathogenic studies and race identification, plasmid profiling of bacteria, fatty acid profiling of bacteria, RFLP profiling of bacteria and variability status, Endospore, Flagella staining; Test for secondary metabolite production, cyanides, EPS, siderophore, specific detection of phytopathogenic bacteria using species/pathovar specific primers; Basic techniques in diagnostic kit development, Molecular tools to identify phytoendosymbionts. Important and emerging diseases and their management strategies.

**SUGGESTED READINGS**

1. Dale, J. W. & Simon, P. 2004. Molecular Genetics of Bacteria. John Wiley & Sons, New York.
2. Garrity, G. M., Krieg, N. R. & Brenner, D. J. 2006. Bergey's Manual of Systematic Bacteriology: The Proteobacteria. Vol. II. Springer Verlag, New York.
3. Gnanamanickam, S. S. 2006. Plant-Associated Bacteria. Springer Verlag, New York.
4. Mount, M. S. & Lacy, G. H. 1982. Plant Pathogenic Prokaryotes. Vols. I, II. Academic Press, New York.
5. Sigee, D. C. 1993. Bacterial Plant Pathology: Cell and Molecular Aspects. Cambridge Univ. Press, Cambridge.
6. Starr, M. P. 1992. The Prokaryotes. Vols. I – IV. Springer Verlag, New York.

## PPATH 613 PRINCIPLES AND PROCEDURES OF CERTIFICATION 1(1+0)

**OBJECTIVE:** To provide a comprehensive understanding of seed certification systems, focusing on international and national standards, quality control mechanisms, and the methods used for testing seed health, genetic identity, and purity.

**COURSE OUTCOME:** The students will be enable to equip with the knowledge to apply seed certification and quality control practices effectively, ensuring the production and trade of healthy, high-quality seeds and planting materials that meet international and national regulatory standards.

**THEORY**

**UNIT-I:** Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD *etc.* in certification and quality control. Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical purity, germination percentage, seed health *etc.* Fixing tolerance limits for diseases and insect pests in certification and quality control programmes.

**UNIT-II:** Methods used in certification of seeds, vegetative propagules and *in vitro* cultures. Accreditation of seed testing laboratories. Role of seed/planting material health certification in national and internationaltrade.

**SUGGESTED READINGS**

1. Association of Official Seed Certifying Agencies. http://www.aosca.org/index.htm.
2. Hutchins, D. & Reeves, J. E. (Eds.). 1997. Seed Health Testing: Progress Towards the 21st Century. CABI, UK.
3. ISHI-veg Manual of Seed HealthTesting Methods. http://www.worldseed.org/enus/international_seed/ishi_vegetable.html ISHI-F Manual of Seed Health Testing Methods. http://www.worldseed.org/en-us/international _seed/ishi_f.html ISTA Seed Health Testing Methods.
4. Tunwar, N. S. & Singh, S. V. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Department of Agriculture and Cooperation, Ministry of Agriculture, Governmentof India, New Delhi. US National Seed Health System. http://www.seedhealth.org.

## PPATH 621 ADVANCES IN MYCOLOGY 3(2+1)

**OBJECTIVE:** To provide an in-depth understanding of fungal biology, taxonomy, genetics, and their interactions with plants and other microorganisms, focusing on the advances in fungal classification, pathogenicity, biotechnology, and the management of mycotoxins.

**COURSE OUTCOME:** The students will be enable to equip with the knowledge to apply fungal taxonomy, genetics, and biotechnological tools in fungal disease management, strain improvement, and the safe use of fungi in agriculture and industry, while understanding their ecological roles and mycotoxin risks.

**THEORY**

**UNIT-I:** General introduction, historical development and advances in mycology. Recent taxonomic criteria, morphological criteria for classification. Serological, chemical (chemotaxonomy), molecular and numerical (computer based assessment) taxonomy. Interaction between groups: Phylogeny, Microconidiation, conidiogenesis and sporulating structures of fungi imperfecti.

**UNIT-II:** Population biology, pathogenic variability/ vegetative compatibility. Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation.

**UNIT-III:** Ultra structures and chemical constituents of fungal cells, functions of cell organelles. Mitosis, meiosis, gene action and regulation. Effects of fungal interaction with host plants and other microorganisms; parasitism, symbiosis and commensalism.

**UNIT-IV:** Genetic Improvement of Fungal strains. Fungal biotechnology. Fungi mediated synthesis of nanoparticles - characterization process and application. Mycotoxins problems and its management.

**PRACTICAL**

Isolation, purification and identification of cultures, spores and mating type determination; Study of conidiogenesis-Phialides, porospores, arthospores; Study of fruiting bodies in Ascomycotina; Identification of fungi up to species level; Study of hyphal anastomosis; Morphology of representative plant pathogenic genera form different groups of fungi; Molecular characterization of fungi.

**SUGGESTED READINGS**


1. Alexopoulos, C. J., Mims, C. W & Blackwell, M. 1996. Introductory Mycology. John Wiley & Sons, New York.
2. Dube, H. C. 2005. An Introduction to Fungi. 3rd Ed. Vikas Publ. House, New Delhi.
3. Kirk, P. M., Cannon, P. F., David, J. C. & Stalpers, J. A. (Eds.). 2001. Ainsworth and Bisby's Dictionary of Fungi. 9th Ed., CABI, Wallington.
4. Maheshwari, R. 2016. Fungi: Experimental Methods in Biology 2nd edn. CRC Press, US.
5. Ulloa, M. & Hanlin, R. T. 2000. Illustrated Dictionary of Mycology. APS, St. Paul, Minnesota.
6. Webster, J. & Weber, R. 2007. Introduction to Fungi. Cambridge Univ. Press, Cambridge.


## PPATH 622 MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION 3(2+1)

**OBJECTIVE:** To provide a comprehensive understanding of host-pathogen interactions, plant immunity, and biotechnological tools used to develop disease-resistant plants, focusing on molecular mechanisms, resistance gene dynamics, and genetic engineering approaches.

**COURSE OUTCOME:** The students will be enable to apply molecular and biotechnological techniques in developing disease-resistant crops, enhancing plant immunity, and understanding the genetic basis of host-pathogen interactions for sustainable disease management in agriculture.

**THEORY**

**UNIT-I:** History of host plant resistance and importance to Agriculture. Importance and role of biotechnological tools in plant pathology. Basic concepts and principles to study host pathogen relationship. Molecular genetics, imaging and analytical chemistry tools for studying plants, microbes, and their interactions.

**UNIT-II:** Different forms of plant-microbe interactions and nature of signals/effectors underpinning these interactions. Plant innate immunity: PAMP/DAMP. Molecular basis of host-pathogen interaction-fungi, bacteria, viruses and nematodes; recognition system, signal transduction.

**UNIT-III:** Induction of defence responses- HR, Programmed cell death, reactive oxygen species, systemic acquired resistance, induced systemic resistance, pathogenesis related proteins, phytoalexins and virus induced gene silencing. Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes. Gene for gene systems: Background, genetics, phenotypes, molecular mechanisms, races, breakdown of resistance (boom-and-bust cycles), Coevolution-arms race and trench warfare models, Metapopulations, cost of resistance, cost of unnecessary virulence, GFG in agricultural crops vs. natural populations, Durability of resistance, erosion of quantitative resistance.

**UNIT-IV:** Pathogen population genetics and durability, viruses *vs.* cellular pathogens. Gene deployment, cultivar mixtures. Disease emergence, host specialization. Circadian clock genes in relation to innate immunity. Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

**PRACTICAL**

Protein, DNA and RNA isolation, plasmid extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation; Gene mapping and marker assisted selection;

Development and use of molecular markers in identification and characterization of resistance to plant pathogens and their management.

**SUGGESTED READINGS**


1. Chet, I. 1993. Biotechnology in Plant Disease Control. John Wiley & Sons, New York.
2. Gurr, S. J., McPohersen, M. J. & Bowlos, D. J. (Eds.). 1992. Molecular Plant Pathology - A Practical Approach. Vols. **I** & **II**, Oxford Univ. Press, Oxford.
3. Mathew, J. D. 2003. Molecular Plant Pathology. Bios Scientific Publ., UK.
4. Ronald, P. C. 2007. Plant-Pathogen Interactions: Methods in Molecular Biology. Humana Press, New Jersey.
5. Stacey, G. & Keen, T. N. (Eds.). 1996. Plant Microbe Interactions. Vols. **I**-**III**.
6. Chapman & Hall, New York; Vol. **IV**. APS Press, St. Paul, Minnesota.


## PPATH 623 PLANT BIOSECURITY AND BIOSAFETY 2(2+0)

**OBJECTIVE:** To provide an in-depth understanding of biosecurity principles, regulatory frameworks, and risk management strategies for protecting plant health, including the role of international agreements, pest and disease forecasting, and biosafety concerns.

**COURSE OUTCOME:** The students will be enable to equip with the knowledge to develop and implement biosecurity measures that mitigate the risks of pests, diseases, and agroterrorism, ensuring safe agricultural practices and compliance with international regulatory standards.

**THEORY**

**UNIT-I:** History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/ resurgence of pests and diseases. Introduction and History of biosecurity and its importance.

**UNIT-II:** National Regulatory Mechanism and International Agreements/Conventions viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures. World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

**UNIT-III:** Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops. Emerging/resurgence of pests and diseases in the changing scenario of climatic conditions. Issues related to release of genetically modified crops.

**SUGGESTED READINGS**


1. FAO Biosecurity Toolkit 2008. www.fao.org/docrep/010/a1140e/a1140e00.htm Laboratory Biosecurity Guidance.
   http://www.who.int/csr/resources/publications/biosafety/WHO_CDS_EPR_2006.pdf.
2. Grotto, A. J. & Jonathan, B. T. 2006. Biosecurity: A Comprehensive Action Plan.
   http://www.americanprogress.org/kf/biosecurity_a_comprehensive_ action_plan.pdf
3. Biosecurity Australia.
   www.daff.gov.au/ba;www.affa.gov.au/biosecurityaustralia Biosecurity NewZealand.
   www.biosecurity.govt.nz DEFRA.
   www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
4. Randhawa, G. J, Khetarpal, R. K., Tyagi, R. K. & Dhillon, B. S. (Eds.). 2001. Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.
5. Khetarpal, R. K. & Gupta, K. 2006. Plant Biosecurity in India - Status and Strategy. *Asian Biotechnology and Development Review* **9(2)**: 3963.
6. Biosecurity for Agriculture and Food Production. http://www.fao.org/biosecurity/

**LIST OF JOURNALS**

- *Annals of Applied Biology* – Cambridge University Press, London
- *Annals of Plant Protection Sciences*- Society of Plant Protection, IARI, New Delhi
- *Annual Review of Phytopathology* – Annual Reviews, Palo Alto, California
- *Annual Review of Plant Pathology* - Scientific Publishers, Jodhpur
- *Canadian Journal of Plant Pathology* - Canadian Phytopathological Society, Ottawa
- *Indian Journal of Biotechnology* - National Institute of Science Communication and Information Resources, CSIR, New Delhi
- *Indian Journal of Mycopathological Research*- Indian Society of Mycology, Kolkata.
- *Indian Journal of Plant Protection*- Plant Protection Association of India, NBPGR, Hyderabad.
- *Indian Journal of Virology* - Indian Virological Society, New Delhi
- *Indian Phytopathology*-Indian Phytopathological Society, IARI New Delhi.
- *Journal of Mycology and Plant Pathology* - Society of Mycology and Plant Pathology, Udaipur.
- *Journal of Plant Disease Science Association of Plant Pathologists* (Central India) PDKV, Akola.
- *Journal of Phytopathology* - Blackwell Verlag, Berlin
- *Mycologia* - New York Botanical Garden, Pennsylvania
- *Mycological Research* - Cambridge University Press, London
- *Physiological Molecular Plant Pathology* - Academic Press, London – Phytopathology - American Phytopathological Society, USA
- *Plant Disease* - The American Phytopathological Society, USA
- *Plant Disease Research* – Indian Society of Plant Pathologists, Ludhiana.
- *Plant Pathology* - British Society for Plant Pathology, Blackwell Publ.
- *Review of Plant Pathology* - CAB International, Wallingford
- *Virology*- New York Academic Press e-Resources
- www.apsjournals.apsnet.org , www.apsnet.org/journals , www.cabi_publishing.org
- www.springer.com/life+Sci/agriculture, www.backwellpublishing.com,
- www.csiro.au

# DEPARTMENT OF ENTOMOLOGY
# AGRICULTURE UNIVERSITY, JODHPUR

**Semester wise Course Title and Credits: M.Sc. (Agri.) Entomology**

| S.No. | Codes | Course titles | Credit hrs. |
|---|---|---|---|
| **Semester-I** | | | |
| 1. | ENTO 511* | Insect Morphology | 3 (2 + 1) |
| 2. | ENTO 512* | Insect Ecology | 3 (2 + 1) |
| 3. | ENTO 513* | Insect Taxonomy | 3 (1 + 2) |
| **Semester-II** | | | |
| 4. | ENTO 521** | Insect Anatomy and Physiology | 3 (2 + 1) |
| 5. | ENTO 522* | Toxicology of Insecticides | 3 (2 + 1) |
| 6. | ENTO 523# | Pests of Field Crops | 3 (2 + 1) |
| 7. | ENTO 524# | Pests of Horticultural and Plantation Crops | 3 (2 + 1) |
| 8. | ENTO 525# | Host Plant Resistance | 2 (1+1) |
| 9. | ENTO 526# | Techniques in Plant Protection | 1 (0+1) |
| 10. | ENTO 527# | Molecular Approaches in Entomology | 3 (2+1) |
| **Semester-III** | | | |
| 11. | ENTO 531** | Biological Control Insect Pests and Weeds | 3 (2 + 1) |
| 12. | ENTO 532# | Concepts of Integrated Pest Management | 2 (2 + 0) |
| 13. | ENTO 533# | Post Harvest Entomology | 2 (1 + 1) |
| 14. | ENTO 534# | Principles of Acarology | 2 (1 + 1) |
| 15. | ENTO 535# | Apiculture | 3 (2+1) |
| 16. | ENTO 536# | Sericulture | 3 (2+1) |
| 17. | ENTO 537# | Lac Culture | 3 (2+1) |
| 18. | ENTO 538# | Insect Vectors of Plant Pathogens | 2 (1+1) |
| 19. | ENTO 539# | Vertebrate Pest Management | 2 (1+1) |
| 20. | ENTO 540# | Plant Quarantine, Biosafety and Biosecurity | 2 (2+0) |
| 21. | ENTO 541# | Edible and Therapeutic Insects | 2 (1+1) |
| 22. | ENTO 542# | Medical and Veterinary Entomology | 2 (1+1) |
| 23. | ENTO 543# | Forest Entomology | 2 (1+1) |
| 24. | ENTO 591 | Master's Seminar | 01 |
| **Semester-IV** | | | |
| 25. | ENTO 598 | Comprehensive | NC |
| 26. | ENTO 599 | Master's Research | 30 |
| 27. | Minor Courses | | 8 |
| 28. | Supporting Courses | | 6 |
| 29. | Common Non-Credit Courses | | 5 NC |

* Core course, ** Compulsory courses, #Optional courses, NC-Non-credit (Satisfactory/ Non-satisfactory).

**Courses Requirement: M.Sc. (Agri.) Entomology**

| | |
|---|---|
| Core Courses and Compulsory Courses | ENTO 511, ENTO 512, ENTO 513, ENTO 521, ENTO 522, ENTO 531 |
| Optional Courses | ENTO 523, ENTO 524, ENTO 525, ENTO 526, ENTO 527, ENTO 532, ENTO 533, ENTO 534, ENTO 535, ENTO 536, ENTO 537, ENTO 538, ENTO 539, ENTO 540, ENTO 541, ENTO 542, ENTO 543 |
| Minor Courses* | PPATH 531, VSC 522, NEMA 506, or any other |
| Supporting Courses* | STAT 512, STAT 521 |
| Non-credit Compulsory Courses | PGS 501, PGS 502, PGS 503, PGS 504 and PGS 505 |
| Seminar | ENTO 591 |
| Comprehensive | ENTO 598 |
| Thesis/Research | ENTO 599 |
| Deficiency courses | Nil or as deemed suitable by advisory committee |

*courses as suggested by Department/Advisory committee/BOS.

**Note:** The minor and supporting courses shall be offered as per schedule of the concerned Department.

**Semester wise Breakup of minimum course load:**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Common compulsory Course (Non-Credit) | Seminar |
|---|---|---|---|---|---|
| I | 3 (9) | 1 (3) | 1 (3) | 3 (3NC) | - |
| II | 2 (6) | 1 (3) | 1 (3) | 2 (2NC) | - |
| III | 2 (5) | 1 (2) | - | - | 1 |
| IV | - | - | - | - | - |

**Note:** Credit load subjected to change as per the requirement or as suggested by HoD.

**Semester Wise Course Title and Credits: Ph.D. Entomology**

| Course Code | Course Title | Credit hours |
|---|---|---|
| **Semester-I** | | |
| ENTO 611* | Insect Phylogeny and Systematics | 3 (1+2) |
| ENTO 612* | Insect Physiology and Nutrition | 3 (2+1) |
| ENTO 613* | Insect Ecology and Diversity | 3 (2+1) |
| ENTO 614# | Insect Behaviour | 2 (1+1) |
| ENTO 615# | Plant Resistance to Insects | 2 (1+1) |
| ENTO 616# | Acarology | 2 (1+1) |
| ENTO 691** | Doctoral Seminar – I | 1 (0+1) |
| **Semester-II** | | |
| ENTO 621** | Bio-inputs for Pest Management | 3 (2+1) |
| ENTO 622** | Insect Toxicology and Residues | 3 (2+1) |
| ENTO 623# | Molecular Entomology | 2 (1+1) |
| ENTO 624# | Integrated Pest Management | 2 (2+0) |
| ENTO 692** | Doctoral Seminar – II | 1 (0+1) |
| **Semester-III to VI** | | |
| ENTO 698** | Preliminary Examination | NC |
| ENTO 699** | Doctoral Research | 75 (0+75) |

*Core course, ** Compulsory courses #Optional courses NC-Non-credit (Satisfactory/ Non satisfactory)

**Note:** The Ph.D. scholar can choose one course: either ENTO 612 or ENTO 613 with the permission of the Head of Department.

**Course Requirement for Ph.D. Entomology**

| | |
|---|---|
| Core and compulsory courses | ENTO 611, ENTO 612 or ENTO 613, ENTO 621, ENTO 622 |
| Optional courses | ENTO 614, ENTO 615, ENTO 616, ENTO 623, ENTO 624 |
| Minor courses* | AGRON 513<br>PPATH 512, PPATH 514, PPATH 522, PPATH 523, PPATH 524<br>PPATH 525, PPATH 526 |
| Supporting courses* | STAT 513, STAT 523 |
| Non-credit compulsory Courses | PGS courses if not studied during Masters |
| Seminar | ENTO 691, ENTO 692 |
| Preliminary Examination | ENTO 698 |
| Thesis/Research | ENTO 699 |
| Deficiency courses | Nil or as deemed suitable by advisory committee |

*courses as suggested by Department/Advisory committee/BOS.

***Note:*** The minor and supporting courses shall be offered as per schedule of the concerned Department.

**Semester wise breakup**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Common compulsory Course (Credit)* | Seminar |
|---|---|---|---|---|---|
| I | 2 (6) | 1 (3) | 1 (3) | 3 (3) | 1 |
| II | 3 (6) | 1 (3) | 1 (3) | 2 (2) | 1 |

*If not studied during Masters**.**

**Examination Pattern: M.Sc. (Agri.) Entomology and Ph.D. Entomology**

| **Particulars** | **Quiz/Assignment** | **Mid Term** | **Final Examination** | |
|---|---|---|---|---|
| | | | **Theory** | **Practical** |
| Courses comprising of Theory & Practical | 5 | 15 | 50 | 30 |
| Courses comprising of Only Theory | 5 | 15 | 80 | - |
| Courses comprising of Only Practical | 5 | 15 | - | 80 |

**Common Non-Credit Courses**

The Ph.D. scholars are exempted from the common non-credit courses as they are expected to have completed these courses during their Master's programme; however, in case a Ph.D. scholar has not offered these common courses (PGS series), he/ she shall have to offer during his/ her doctoral programme.

# COURSE CONTENTS: M.Sc. (Agri.) ENTOMOLOGY

## ENTO 511 INSECT MORPHOLOGY 3 (2+1)

**AIM OF THE COURSE**

To acquaint the students with the external morphology of the insect's body and the functioning of various body parts.

**COURSE OUTCOME**

Students are expected to have a complete understanding of the comparative morphology of the external features of insects that can be utilized in taxonomy, ecology and applied entomology.

**THEORY**

**UNIT-I:** External Morphology: Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation.

Head- Origin, structure and modification; mouthparts, antennae, their types and functioning; tentorium and neck sclerites.

Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; legs: structure and modifications.

Abdomen- Segmentation and appendages; genitalia and their modifications; embryonic and post-embryonic development.

**UNIT-II:** Insect sense organs (mechano-photo and chemo- receptors); organogenensis at pupal stage; insect defense; chaetotaxy; morphological traits in relation to forensic entomology.

**UNIT-III:** Types of immature stages in insect orders, morphology of egg, nymph/ larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in hemi-metabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

**PRACTICAL**

- Preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia;
- Dissection of genitalia. Types of immature stages in insects; their collection, rearing and preservation;
- Identification of immature insects to orders and families, in endopterygote orders, viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using key;

**SUGGESTED READINGS**

1. Chapman, R. F. 1998. The Insects: Structure and Function. Cambridge Univ. Press, Cambridge, Chu, H. F. 1992. How to Know Immature Insects. William Brown Publication, Iowa.
2. Duntson, P. A. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publishers, New Delhi.
3. Evans, J. W. 2004. Outlines of Agricultural Entomology. Asiatic Publ., New Delhi.
4. Gillott, C. 1995. Entomology, 2nd Ed. Plenum Press, New York, London.
5. Gullan, P. J. and Cranston, P. S. 2000. The Insects, An Outline of Entomology, 2nd Ed. Blackwell Science, UK.
6. Peterson, A. 1962. Larvae of Insects. Ohio University Press, Ohio.
7. Richards, O. W. and Davies, R. G. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman and Hall, London.
8. Snodgross, R. E. 1993. Principles of Insect Morphology. Cornell Univ. Press, Ithaca.
9. Tembhore, D. B. 2000. Modern Entomology, Himalaya Publishing House, Mumbai.
10. Stehr, F. W. 1998. Immature Insects. Vols. I, II. Kendall Hunt Publication, Iowa.

## ENTO 512 INSECT ECOLOGY 3 (2+1)

**AIM OF THE COURSE**

To teach the concepts of ecology, basic principles of distribution and abundance of organisms and their causes. Study life tables, constructing life tables, organization of communities, diversity indices. Train students in sampling methodology, calculation of diversity indices, relating insect population fluctuations to biotic and/ or abiotic causes.

**COURSE OUTCOME**

1. The students are expected to be well versed with the basic concepts of ecology, ecological succession, population ecology, community ecology, nutritional ecology and different insect-ecosystem interactions.
2. Quantification of insect diversity and abundance, life table analyses, predator- prey and host-parasitoid relations, functional and numerical responses, niche breadth and overlap.

**THEORY**

**UNIT-I:** History and definition. Basic Concepts. Organisation of the Biological world. Plato's. Natural Balance *vs.* Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology.

**UNIT-II:** Basic concepts of abundance- Model *vs.* Real world. Population growth basic models– Exponential *vs.* Logistic models. Discrete *vs.* Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality-Diapause (Quiescence) – aestivation, hibernation.

**UNIT-III:** Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions– The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of niche ecological homologues, competitive exclusion. Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.

**UNIT-IV:** Community ecology- Concept of guild, Organization of communities- Hutchinson Ratio, May's d/w, Relation between the two and their association with Dyar's Law and Przibram's law. Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity- stability debate, relevance to pest management. Pest management as applied ecology. Climate change and insect pest/ natural enemy population; ecological engineering.

**PRACTICAL**

- Types of distributions of organisms;
- Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution;
- Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit;
- Fitting Holling's Disc equation;
- Assessment of prey-predator densities from natural systems and understanding the correlation between the two;
- Assessing and describing niche of some insects of a single guild;
- Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms;
- Calculation of diversity indices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values;
- Problem solving in ecology. Field visits to understand different ecosystems and to study insect

occurrence in these systems.

**SUGGESTED READINGS**


1. Begon, M, Townsend, C. R. and Harper, J. L. 2006. Ecology: From Individuals to Ecosystems. 4th Ed. Blackwell Publishing, USA/ UK/ Australia.
2. Chapman, J. L. and Reiss, M. J. 2006. Ecology: Principles and Applications. 2nd Ed. Cambridge Univ. Press, Cambridge.
3. Fowler, J. Cohen, L. and Jarvis, P. 1998. Practical Statistics for Field Biology. 2nd Ed. John Wiley & Sons, Chichester, West Sussex PO19 8SQ, England.
4. Gotelli, N. J. and Ellison, A. M. 2004. A Primer of Ecological Statistics. Sinauer Associates, Inc., Sunderland, MA.
5. Gotelli, N. J. 2001. A Primer of Ecology. 3rd Ed. Sinauer Associates, Inc., Sunderland, MA Gupta RK. 2004. Advances in Insect Biodiversity. *Agrobios*, Jodhpur.
6. Krebs, C. J. 1998. Ecological Methodology. 2nd Ed. Benjamin-Cummings Publ. Co., New York. Krebs, C. J. 2001. Ecology: The Experimental Analysis of Distribution and Abundance. 5th Ed. Benjamin-Cummings Publ. Co., New York.
7. Magurran, A. E. 1988. Ecological Diversity and its Measurement. Princeton Univ. Press, Princeton.
8. Price, P. W. 1997. Insect Ecology. 3rd Ed. John Wiley, New York.
9. Real, L. A. and Brown, J. H. (Eds). 1991. Foundations of Ecology: Classic Papers with Commentaries. University of Chicago Press, Chicago.
10. Schowalter, & Timothy, D. 2011. Insect Ecology – An Ecosystem Approach. 3rd Ed. Academic Press, London, UK/ CA, USA.
11. Southwood, T. R. E. and Henderson, P. A. 2000. Ecological Methods. 3rd Ed. Methuen and Co. Ltd., London.
12. Speight, M. R., Hunta, M. D. and Watt, A. D. 2006. Ecology of Insects: Concepts and Application. Elsevier Science Publ., The Netherlands.
13. Townsend Colin, R., Begon, M. and Harper, J. L. 2008. Essentials of Ecology. 3rd Ed. Blackwell Publishing, USA/ UK/ Australia.
14. Wilson, E. O., William, H. and Bossert, W. H. 1971. A Primer of Population Biology. Harvard University, USA.
15. Wratten, S. D. and Fry, G. L. A. 1980. Field and Laboratory Exercises in Ecology. Arnold, London.


## ENTO 513 — INSECT TAXONOMY — 3 (1+2)

**AIM OF THE COURSE**

To sensitize the students on the theory and practice of classifying organisms (with special reference to animals) and the rules governing the same. To introduce the students to the classification of insects up to the level of families with hands-on experience in identifying the families of insects with an emphasis on the practical aspects.

**COURSE OUTCOME**

1. Students are expected to know the evolution of arthropods, especially insects and other hexapods, and their hierarchical classification.
2. Acquire working skills for collecting, mounting, and preserving insects.
3. Understand the basic concepts of taxonomic hierarchy, identification, taxonomic characters, variations, taxonomic keys and preparation of taxonomic papers.
4. Identify insects of economic importance up to family levels, taking up the insect orders of agriculture and veterinary importance.

**THEORY**

**UNIT-I:** History of insect classification; principles of systematics and its importance. Identification, purpose, methods character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy *v/s* homology, parallel *v/s* convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism. Brief evolutionary history of insects- introduction to phylogeny of insects and Classification of

Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses. Process of speciation and interbreeding allopatric species. Molecular systemnatics, DNA barcoding, karyological and biochemical approaches in taxonomy. Insect labeling protocols and procedures.

**UNIT-II:** Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.

**UNIT-III:** Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

**PRACTICAL**

- Study of Orders of insects and their identification using taxonomic keys;
- Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera;
- Field visits to collect insects of different orders.

**SUGGESTED READINGS**


1. CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.
2. Freeman, S. and Herron, J. C. 1998. Evolutionary Analysis. Prentice Hall, New Delhi.
3. Gullan, P. J. and Cranston, P. S. 2010. The Insects: An outline of Entomology. 4th Ed. Wiley-Blackwell Publications, West Sussex, UK.
4. Mayr, E. 1971. Principles of Systematic Zoology. Tata McGraw Hill, New Delhi.
5. Richards, O. W. and Davies, R. G. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman and Hall, London.
6. Ross, H. H.1974. Biological Systematics. Addison Wesley Publ. Company.
7. Triplehorn, C. A. and Johnson, N. F. 1998. Borror and DeLong's Introduction to the Study of Insects.7th Ed. Thomson/ Brooks/ Cole, USA/ Australia.


## ENTO 521 INSECT ANATOMY AND PHYSIOLOGY 3 (2+1)

**AIM OF THE COURSE**

To impart knowledge about the anatomy and physiology of insect body systems; nutritional physiology; and their applications in entomology.

**COURSE OUTCOME**

Students are expected to have a thorough understanding of insect growth and development, physiology of exoskeleton, endoskeleton and different organ systems; action and role of hormones, pheromones, physiology of nutrition and its application.

**THEORY**

**UNIT-I:** Scope and importance of insect physiology; physiology of integument, moulting, chemistry of cuticle, biosysthesis of chitin; growth, hormonal control, metamorphosis and diapause; pheromone secretion, transmission, perception and reception.

**UNIT-II:** Physiology and mechanism of digestion, circulation, respiration, excretion, reproduction, secretion (exocrine and endocrine glands) and nerve impulse transmission in insects.

**UNIT-III:** Importance of insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.

**PRACTICAL**

- Latest analytical techniques for analysis of free amino acids of haemolymph;
- Determination of chitin in insect cuticle;
- Examination and count of insect haemocytes; preparation and evaluation of various diets;
- Consumption, utilization and digestion of natural and artificial diets.

**SUGGESTED READINGS**

1. Chapman, R. F. 1998. Insects: Structure and Function. ELBS Ed., London.
2. Duntson, P. A. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publishers, New Delhi.
3. Gullan, P. J. and Cranston, P. S. 2000. The Insects: An Outline of Entomology, 2$^{nd}$ Ed. Blackwell Science, UK.
4. Kerkut, G. A. and Gilbert, L. I. 1985. Comprehensive Insect Physiology, Biochemistry and Pharmacology. Vols. I-XIII. Pergamon Press, New York.
5. Patnaik, B. D. 2002. Physiology of Insects. Dominant Publishers, New Delhi.
6. Richards, O. W. and Davies RG. 1977. Imm's General Text Book of Entomology. 10$^{th}$ Ed. Vol.1. Structure, Physiology and Development. Chapman and Hall, New York.
7. Simpson, S. J. 2007. Advances in Insect Physiology, Vol. 33, Academic Press (Elsevier), London, UK.
8. Wigglesworth, V. B. 1984. Insect Physiology. 8$^{th}$ Ed. Chapman and Hall, New York.

## ENTO 522 TOXICOLOGY OF INSECTICIDES 3 (2+1)

**AIM OF THE COURSE**

To orient the students with structure and mode of action of important insecticides belonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

**COURSE OUTCOME**

Students are expected understand the concept of toxicity, bio-efficacy, insecticide formulations, modes of action of insecticides, estimation of insecticide residues and have significant know-how about the functioning of various types of spray equipments.

**THEORY**

**UNIT-I:** Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

**UNIT-II:** Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature; categorization of insecticides on the basis of toxicity – criteria for bees, beneficial insects and other insects in general; structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds/ new insecticide molecules; nanopesticides; drawbacks of insecticide abuse.

**UNIT-III:** Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides-synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity. bioassay definition, objectives, criteria, factors, problems and solutions.

**UNIT-IV:** Insecticide metabolism; insect-pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

**UNIT-V:** Insecticide residues, their significance and environmental implications; procedures of insecticide residue analysis. Insecticide Act, registration procedures, label claim, and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

**PRACTICAL**

- Insecticide formulations and mixtures;
- Laboratory and field evaluation of bio-efficacy of insecticides;
- Bioassay techniques;
- Probit analysis;
- Evaluation of insecticide toxicity;
- Toxicity to beneficial insects;
- Pesticide appliances;
- Working out doses and concentrations of pesticides;
- Procedures of residue analysis.

**SUGGESTED READINGS**


1. Chattopadhyay SB. 1985. Principles and Procedures of Plant Protection. Oxford and IBH, New Delhi.
2. Dodia DA, Petel IS and Petal GM. 2008. Botanical Pesticides for Pest Management. Scientific Publisher (India), Jodhpur.
3. Dovener RA, Mueninghoff JC and Volgar GC. 2002. Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA
4. Gupta HCL.1999. Insecticides: Toxicology and Uses. Agrotech Publ., Udaipur.
5. Ishaaya I and Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.
6. Ishaaya I and Degheele D. 1998. Insecticides with Novel Modes of Action: Mechanism and Application. Norosa Publishing House, New Delhi.
7. Krieger RI. 2001. Handbook of Pesticide Toxicology. Vol-II. Academic Press. Orlando Florida.
   Mathews GA. 2002. Pesticide Application Methods. 4th Ed. Intercept. UK.
8. Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York.
9. Otto D and Weber B. 1991. Insecticides: Mechanism of Action and Resistance. Intercept Ltd., UK.
10. Pedigo LP and Marlin ER. 2009. Entomology and Pest Management, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.
11. Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi.
12. Prakash A and Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publication, New York.
    Roy NK. 2006. Chemistry of Pesticides. Asia Printograph Shahdara, New Delhi.


## ENTO 523 PESTS OF FIELD CROPS 3 (2+1)

**AIM OF THE COURSE**

To familiarize the students about nature of damage and seasonal incidence of pestiferous insects that cause loss to major field crops and their effective management by different methods.

**COURSE OUTCOME**

Students are expected to acquire knowledge of insect pests of field crops, their nature of damage, life history traits and effective management.

**THEORY**

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors. Insect pest scenario in relation to climate change.

**UNIT-I:** Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs, *etc*.). Insect pests of cereals and millets and their management.

**UNIT-II:** Insect pests of pulses, tobacco, oilseeds and their management.

**UNIT-III:** Insect pests of fibre crops, forage crops, sugarcane and their management.

**PRACTICAL**

- Field visits, collection and identification of important pests and their natural enemies;
- Detection and estimation of infestation and losses in different crops;

- Study of life history of important insect pests.

**SUGGESTED READINGS**


1. David, BV and Ramamurthy, VV. 2001. *Elements of Economic Entomology.* Popular Book Depot, Chennai.
2. Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essentials of Agricultural Entomology.* Kalyani Publishers, New Delhi.
3. Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publishers, New Delhi Evans JW. 2005. *Insect Pests and their Control*. Asiatic Publ., New Delhi.
4. Nair MRGK. 1986. *Insect and Mites of Crops in India.* ICAR, New Delhi. Prakash I and Mathur RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.
5. Saxena RC and Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Udaipur.


## ENTO 524 PESTS OF HORTICULTURAL AND PLANTATION CROPS 3 (2+1)

**AIM OF THE COURSE**

To impart knowledge on major pests of horticultural and plantation crops regarding the extent and nature of loss, seasonal history, their integrated management.

**COURSE OUTCOME**

Students are expected to acquire knowledge of insect pests of horticultural, medicinal and plantation crops, their nature of damage, life history traits and effective management.

**THEORY**

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops.

**UNIT-I:** Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits.

**UNIT-II:** Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, French beans, chow-chow, brinjal, okra, all gourds, drumstick, leafy vegetables, *etc*.

**UNIT-III:** Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa, *etc*.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine, *etc*.

**UNIT-IV:** Ornamental, medicinal and aromatic plants and pests in polyhouses/ protected cultivation.

**PRACTICAL**

- Collection and identification of important pests and their natural enemies on different crops;
- Study of life history of important insect pests and non-insect pests.

**SUGGESTED READINGS**


1. Atwal AS and Dhaliwal GS. 2002. Agricultural Pests of South Asia and their Management. Kalyani Publishers, New Delhi.
2. Butani DK and Jotwani MG. 1984. Insects and Vegetables. Periodical Expert Book Agency, New Delhi.
3. Dhaliwal GS, Singh R and Chhillar BS. 2006. Essential of Agricultural Entomology. Kalyani Publishers, New Delhi.
4. Srivastava RP. 1997. Mango Insect Pest Management. International Book Distr., Dehra Dun. Verma LR, Verma AK and Goutham DC. 2004. Pest Management in Horticulture Crops: Principles and Practices. Asiatech Publ., New Delhi.


## ENTO 525 HOST PLANT RESISTANCE 2 (1+1)

**AIM OF THE COURSE**

To orient the students with host plant resistance.

**COURSE OUTCOME**

Students are expected to acquire a thorough knowledge of the types and basis of mechanisms involved in host plant resistance, screening techniques to measure resistance and insect resistance breeding.

**THEORY**

**UNIT-I:** History and importance of resistance; principles, classification, components, types and mechanisms of resistance.

**UNIT-II:** Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

**UNIT-III:** Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance– acquired and induced systemic resistance.

**UNIT-IV:** Factors affecting plant resistance including biotypes and measures to combat them.

**UNIT-V:** Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

**UNIT-VI:** Role of biotechnology in plant resistance to insects.

**PRACTICAL**

- Screening techniques for measuring resistance;
- Measurement of plant characters and working out their correlations with plant resistance;
- Testing of resistance in important crops;
- Bioassay of plant extracts of susceptible/ resistant varieties;
- Demonstration of antibiosis, tolerance and antixenosis.

**SUGGESTED READINGS**

1. Dhaliwal GS and Singh R. (Eds). 2004. Host Plant Resistance to Insects -Concepts and Applications. Panima Publ., New Delhi.
2. Maxwell FG and Jennings PR. (Eds). 1980. Breeding Plants Resistant to Insects. John Wiley and Sons, New York.
3. Painter RH. 1951. Insect Resistance in Crop Plants. MacMillan, London. Panda N and Khush GS. 1995. Plant Resistance to Insects. CABI, London.
4. Smith CM. 2005. Plant Resistance to Arthropods – Molecular and Conventional Approaches. Springer, Berlin.

## ENTO 526 TECHNIQUES IN PLANT PROTECTION 1 (0+1)

**AIM OF THE COURSE**

To acquaint the students with appropriate use of plant protection equipments and techniques related to microscopy, computation, pest forecasting, *etc*.

**COURSE OUTCOME**

Students are expected to have a good knowledge of different plant protection equipments and techniques related to pest forecasting.

**PRACTICAL**

- Pest control equipments, principles, operation, maintenance, selection, and application of pesticides;
- Release of bio-control agents;
- Seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticide application through irrigation water;
- Application of drones in plant protection;
- Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers;
- Uses of light, transmission and scanning electron microscopy;
- Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/ PAGE;
- Use of tissue culture techniques in plant protection;
- Computer application for predicting/ forecasting pest attack and identification.

**SUGGESTED READINGS**

1. Alford DV. 1999. A Textbook of Agricultural Entomology. Blackwell Science, London. Crampton JM and Eggleston P. 1992. Insect Molecular Science. Academic Press, London.

## ENTO 527 MOLECULAR APPROACHES IN ENTOMOLOGY 3 (2+1)

**AIM OF THE COURSE**

To acquaint students the latest techniques used in molecular biology.

**THEORY**

**UNIT-I:** Introduction to molecular biology, techniques used in molecular biology.

**UNIT-II:** DNA recombinant technology, identification of genes/ nucleotide sequences for traits of interest, techniques of interest in plants and microbes.

**UNIT-III:** Genes of interest in entomological research- marker genes for sex identification, peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Plant- derived enzyme inhibitors, protease inhibitors, trypsin inhibitors, á-amylase inhibitors, lectins, terepenes and terpenoids; genes of non-plant origin, *Bacillus thuringiensis* endotoxins, mode of action of cry genes, classification and properties, synthetic Bt toxin genes, Other toxin genes, genes derived from entomophagous viruses, transgenic plants for pest resistance.

**UNIT-IV:** Genetically engineered microbes and parasitoids in biological control-Genetic engineering in baculoviruses and fungal biocontrol agents for greater efficacy against insect pests. Effects of transgenic plants on pest biology and development, resistance management strategies in transgenic crops, molecular mechanism of insecticide resistance.

**UNIT-V:** Genetic-based methods for agricultural insect pest management-insect pest management through sterile insect technique and release of insects carrying a dominant lethal gene. Methods and application of insect trangenesis, transgenics in silkworm and honeybees. Molecular tools for taxonomy and phylogeny of insect- pests, DNA-based diagnostics. Nano technology and its application.

**PRACTICAL**

- Isolation of DNA/ RNA;
- Agarose gel electrophoresis of DNA, quantification of DNA by spectrophotometirc and agarose gel analysis, PCR amplification of mitochondrial cytochrome oxidase sub unit gene (*cox1*) and 16S rRNA gene, cloning of PCR amplicons in standard plasmid vectors for sequencing, confirmation of the insert, miniprep of recombinant plasmid DNA, BLAST analysis and multiple sequence alignment of the sequence with sequences already available in Gen Bank;
- Isolation of host plant proteins, SDS-PAGE of the isolated proteins.

**COURSE OUTCOME**

The students are expected to be well versed with the basic techniques used in molecular biology.

**SUGGESTED READINGS**


1. Bhattacharya TK, Kumar P and Sharma A. 2007. Animal Biotechnology. 1st Ed., Kalyani Publication, New Delhi.
2. Hagedon HH, Hilderbrand JG, Kidwell MG and Law JH. 1990. Molecular Insect Science. Plenum Press, New York.
3. Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York.
4. Oakeshott J and Whitten MA. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer Verlag.
5. Rechcigl JE and Rechcigl NA. 1998. Biological and Biotechnological Control of Insect Pests.
6. Lewis Publ., North Carolina.
7. Roy U and Saxena V. 2007. A Hand Book of Genetic Engineering. 1st Ed., Kalyani Publishers, New Delhi.
8. Singh BD. 2008. Biotechnology (Expanding Horizons). Kalyani Publishers, New Delhi. Singh P. 2007. Introductory to Biotechnology. 2nd Ed. Kalyani Publishers, New Delhi.

## ENTO 531 BIOLOGICAL CONTROL OF INSECT PESTS AND WEEDS 3(2+1)

**AIM OF THE COURSE**

To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

**COURSE OUTCOME**

Students are expected to have a good understanding of the role of natural enemies in managing pest populations below those causing economic damage. Learn the techniques for mass production of quality bio-agents and their optimal use in IPM.

**THEORY**

**UNIT-I:** History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.

**UNIT-II:** Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa *etc.*, their mode of action. Biological control of weeds using insects. Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defence mechanisms in insects against pathogens.

**UNIT-III:** Mass production of quality bio-control agents- techniques, formulations, economics, field release/ application and evaluation. Development of insectaries, their maintenance.

**UNIT-IV:** Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

**PRACTICAL**

- Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers;
- Visits to bio-control laboratories to learn rearing and mass production of egg, egg- larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds;
- Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

**SUGGESTED READINGS**


1. Burges HD and Hussey NW. (Eds). 1971. Microbial Control of Insects and Mites. Academic Press, London.
2. De Bach P. 1964. Biological Control of Insect Pests and Weeds. Chapman and Hall, New York. Dhaliwal GS and Arora R. 2001. Integrated Pest Management: Concepts and Approaches. Kalyani Publishers, New Delhi.
3. Gerson H and Smiley RL. 1990. Acarine Biocontrol Agents – An Illustrated Key and Manual. Chapman and Hall, New York.
4. Huffaker CB and Messenger PS. 1976. Theory and Practices of Biological Control. Academic Press, London.
5. Ignacimuthu SS and Jayaraj S. 2003. Biological Control of Insect Pests. Phoenix Publ., New Delhi. Saxena AB. 2003. Biological Control of Insect Pests. Anmol Publ., New Delhi.
6. Van Driesche and Bellows TS. Jr. 1996. Biological Control. Chapman and Hall, New York.


## ENTO 532 CONCEPTS OF INTEGRATED PEST MANAGEMENT 2 (2+0)

**AIM OF THE COURSE**

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM**.** Train students in computation of ETL and implementing IPM programmes.

**COURSE OUTCOME**

Students are expected to have significant knowledge of IPM concepts, estimation of losses due to insect pests, computation of ETL, EIL and should be able take management decisions.

**THEORY**

**UNIT-I:** History, origin, definition and evolution of various terminologies. Importance of resistance, principles, classification, components, types and mechanisms of resistance. National and international level crop protection organizations; insecticide regulatory bodies; synthetic insecticide, bio-pesticide and pheromone registration procedures; label claim of pesticides– the pros and cons.

**UNIT-II:** Concept and philosophy, ecological principles, economic threshold concept and economic consideration. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

**UNIT-III:** Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; semiochemicals, biotechnological and bio-rational approaches in IPM. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost- benefit ratios and partial budgeting; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organic farming; components of ecological engineering with successful examples.

**UNIT-IV:** Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses; global and Indian scenario of crop losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system. Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

**SUGGESTED READINGS**

1. Dhaliwal GS and Arora R. 2003. Integrated Pest Management – Concepts and Approaches.
2. Kalyani Publishers, New Delhi.
3. Horowitz AR and Ishaaya I. 2004. Insect Pest Management: Field and Protected Crops. Springer, New Delhi.
4. Ignacimuthu SS and Jayaraj S. 2007. Biotechnology and Insect Pest Management. Elite Publ., New Delhi.
5. Norris RF, Caswell-Chen EP and Kogan M. 2002. Concepts in Integrated Pest Management. Prentice Hall, New Delhi.
6. Pedigo RL. 2002. Entomology and Pest Management. 4th Ed. Prentice Hall, New Delhi. Subramanyam B and Hagstrum DW. 1995. Integrated Management of Insects in Stored Products. Marcel Dekker, New York.

| ENTO 533 | POST HARVEST ENTOMOLOGY | 2 (1+1) |
|---|---|---|

**AIM OF THE COURSE**

To focus on requirement and importance of grain and grain storage, to understand the role of stored grain pests and to acquaint with various stored grain pest management techniques for avoiding losses in storage.

**COURSE OUTCOME**

1. Students are expected to acquire knowledge of pestiferous insects, mites, rats and birds affecting stored produce, their nature of damage, life history traits and effective management.
2. Detection of insect infestation and familiarization with different storage structures.
3. Learning preventive and curative measures to manage infestation in storage houses.

**THEORY**

**UNIT-I:** Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses *in toto vis-à-vis* total production of food grains in India. Scientific and socio-economic factors responsible for grain losses. Concept of seed vault.

**UNIT-II:** Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.

**UNIT-III:** Ecology of insect pests of stored commodities/ grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.

**UNIT-IV:** Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/ sanitation, disinfestations of stores/ receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical control- prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Insecticide resistance in stored product pests and its management; recent advances (MAS, PPP, HS) in storage pest management; integrated approaches to stored grain pest management.

**PRACTICAL**

- Collection, identification and familiarization with the stored grains/ seed insect pests and nature of damage caused by them;
- Detection of hidden insect infestation in stored food grains;
- Estimation of uric acid content in infested produce; estimation of losses in stored food grains;
- Determination of moisture content in stored food grains;
- Familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques;
- Treatment of packing materials and their effect on seed quality;
- Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, Mysore; IGSMRI, Hapur, *etc.* (only where logistically feasible).

**SUGGESTING READINGS**

1. Hall DW. 1970. Handling and Storage of Food Grains in Tropical and Subtropical Areas. FAO. Agricultural Development Paper No. 90 and FAO, Plant Production and Protection Series No. 19, FAO, Rome.
2. Jayas DV, White NDG and Muir WE. 1995. Stored Grain Ecosystem. Marcel Dekker, New York.
3. Khader V. 2004. Textbook on Food Storage and Preservation. Kalyani Publishers, New Delhi.
4. Khare BP. 1994. Stored Grain Pests and Their Management. Kalyani Publishers, New Delhi.
5. Subramanyam B and Hagstrum DW. 1995. Interrelated Management of Insects in Stored Products. Marcel Dekker, New York.

## ENTO 534 PRINCIPLES OF ACAROLOGY 2 (1+1)

**AIM OF THE COURSE**

To acquaint the students with external morphology of different groups of mites, train in identification of commonly occurring families of plant associated mites, provide information about important mite pests of crops and their management.

**COURSE OUTCOME**

1. Students are expected to identify mites up to family level.
2. Acquire knowledge of mite pests of cultivated crops, their nature of damage, life history traits and effective management.

**THEORY**

**UNIT-I:** History of Acarology; importance of mites as a group; habitat, collection and preservation of mites. Soil arthropods and their classification, habitats and their identification.

**UNIT-II:** Introduction to morphology and biology of mites and ticks. Broad classification- major orders and important families of Acari including diagnostic characteristics. Estimation of populations; sampling and extraction methods for soil arthropods.

**UNIT-III:** Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens, *etc.* Culturing of phytophagous, parasitic and predatory mites. Mode of action of acaricides, resistance of mites and ticks to acaricides, its management.

**PRACTICAL**

- Collection of mites from plants, soil and animals;
- Extraction of mites from soil, plants and stored products;
- Preparation of mounting media and slide mounts;
- External morphology of mites;
- Identification of mites up to family level using keys;
- Studying different rearing techniques for mites.

**SUGGESTED READINGS**

1. Anderson JM and Ingram JSI. 1993. *Tropical Soil Biology and Fertility: A Handbook of Methods.* CABI, London.
2. Chhillar BS, Gulati R and Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ. House, New Delhi.
3. Dindal DL. 1990. *Soil Biology Guide*. A Wiley-InterScience Publ., John Wiley and Sons, New York.
4. Gerson U and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman and Hall, New York.
5. Gupta SK. 1985. *Handbook of Plant Mites of India.* Zoological Survey of India, Calcutta. Gwilyn O and Evans GO. 1998. *Principles of Acarology*. CABI, London.
6. Jeppson LR, Keifer HH and Baker EW. 1975. *Mites Injurious to Economic Plants*. University of California Press, Berkeley.
7. Krantz GW. 1970. *A Manual of Acarology.* Oregon State Univ. Book Stores, Corvallis, Oregon. Pankhurst C, Dube B and Gupta, V. 1997. *Biological Indicators of Soil Health.* CSIRO, Australia.
8. Qiang Zhiang Z. 2003. *Mites of Green Houses- Identification, Biology and Control*. CABI, London.
9. Sadana GL. 1997. *False Spider Mites Infesting Crops in India.* Kalyani Publishers House, New Delhi.
10. Walter DE and Proctor HC. 1999. *Mites- Ecology, Evolution and Behaviour*. CABI, London.
11. Veeresh GK and Rajagopal D. 1988. *Applied Soil Biology and Ecology*. Oxford and IBH Publ., New Delhi.

| ENTO 535 | APICULTURE | 3 (2+1) |
|---|---|---|

**AIM OF THE COURSE**

To impart knowledge about the honey bees, and their behaviour and activities; bee husbandry, bee multiplication, bee enemies and diseases and their management; hive products, apitherapy; and managed bee pollination of crops

**COURSE OUTCOME**

1. Students are expected to have a comprehensive knowledge of bee biology, physiology and bee keeping/ apiculture.
2. With practical training it is expected that students develop entrepreneurial skills for apiculture.

**THEORY**

**UNIT-I:** Historical development of apiculture at global level and in India; Classification of bees; global distribution of genus *Apis* and races; Morphology and anatomy of honey bee; Honey bee biology, ecology, adaptations; Honey bee behaviour – nest founding, comb construction, brood care, defence, other in-house and foraging activities; Bee pheromones; Honey bee communication.

**UNIT-II:** Commercial beekeeping as an enterprise; Design and use of bee hives; Apicultural equipment; Seasonal bee husbandry; Honey bee nutrition and artificial diets; Absconding, swarming, drifting – causes and management; Curbing drone rearing; Laying worker menace – causes, signs and management.

**UNIT-III:** Bee genetics; Principles and procedures of bee breeding; Screening of honey bee colonies; Techniques in mass queen bee rearing; Mating nuclei and their establishment; Selective mating; Queen bee management; Bee packages.

**UNIT-IV:** Ectoparasitic and endoparasitic bee mites – biology, ecology, nature and symptoms of damage, management tactics; Wax moths, wasps and ants – biology, ecology, nature and symptoms of damage, management tactics; Predatory birds, their damage potential and management tactics; Pesticide poisoning to honey bees, signs and protection; Protocols in evaluation of pesticide toxicity to honey bees.

**UNIT-V:** Honey – composition, properties, crystallization, post-harvest handling and processing; Honey quality standards and assessment; Apicultural diversification – potential and profitability; Production/ collection of bee pollen, propolis, royal jelly, bee venom and bees wax and their post-harvest handling; Apitherapy; Value addition of hive products; Development of apiculture project.

**UNIT-VI:** Non-*Apis* pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops.

**PRACTICAL**

- Morphological characteristics of honey bee;
- Mouthparts; digestive, respiratory and reproductive adaptations in different castes of honey bees;
- Recording of colony performance;
- Seasonal bee husbandry practices;
- Swarming, queenlessness, swarming, laying workers menaces, *etc*. and their remedies;
- Innovative techniques in mass queen bee rearing; selection and breeding of honey bees;
- Instrumental insemination; formulation of artificial diets and their feeding;
- Production technologies for various hive products;
- Bee enemies and diseases and their management;
- Recording pollination efficiency;
- Application of various models for determining pollination requirement of crop;
- Developing a beekeeping project.

**SUGGESTED READINGS**

1. Abrol DP and Sharma D. 2009. Honey Bee Mites and Their Management. Kalyani Publishers, New Delhi, India.
2. Abrol DP. 2009. Honey bee Diseases and Their Management. Kalyani Publishers, New Delhi, India.
3. Abrol DP. 2010. Beekeeping: A Compressive Guide to Bees and Beekeeping. Scientific Publishers, India.
4. Abrol DP. 2010. Bees and Beekeeping in India. Kalyani Publishers, New Delhi, India.
5. Abrol DP. 2012. Pollination Biology: Biodiversity Conservation and Agricultural Production. Springer.
6. Atwal AS. 2001. World of Honey Bees. Kalyani Publishers, New Delhi- Ludhiana, India.
7. Atwal AS. 2000. Essentials of Beekeeping and Pollination. Kalyani Publishers, New Delhi-Ludhiana, India.
8. Bailey L and Ball BV. 1991. Honey Bee Pathology. Academic Press, London.
9. Crane Eva and Walker Penelope. 1983. The Impact of Pest Management on Bees and Pollination. Tropical Development and Research and Institute, London.
10. Free JB. 1987. Pheromones of Social Bees. Chapman and Hall, London.
11. Gatoria GS, Gupta JK, Thakur RK and Singh Jaspal. 2011. Mass Multiplication of Honey Bee Colonies. ICAR, New Delhi, India.
12. Grahm Joe M. 1992. Hive and the Honey Bee. Dadant & Sons, Hamilton, Illinois, USA.
13. Grout RA. 1975. Hive and the Honey Bee. Dadant & Sons, Hamilton, Illinois, USA. Holm E. 1995. Queen Rearing Genetics and Breeding of Honey Bees. Gedved, Denmark.

14. Laidlaw HH Jr and Eckert JE. 1962. Queen Rearing. Berkeley, University of California Press.
15. Laidlaw HH. 1979. Contemporary Queen Rearing. Dadant & Sons, Hamilton, Illinois, USA.
16. Mishra RC. 2002. Perspectives in Indian Apiculture. Agro-Botanica, Jodhpur, India.
17. Mishra RC. 1995. Honey Bees and their Management in India. I.C.A.R., New Delhi, India.
18. Morse AA. 1978. Honey Bee Pests, Predators and Diseases. Cornell University Press, Ithaca and London.
19. Rahman, A. 2017. Apiculture in India, ICAR, New Delhi
20. Ribbands CR. 1953. The Behaviour and Social Life of Honey Bees. Bee Research Association Ltd., London, UK.
21. Rinderer TE. 1986. Bee Genetics and Breeding. Academic Press, Orlando.
22. Sardar Singh. 1962. Beekeeping in India. I.C.A.R., New Delhi, India (Reprint: 1982). Seeley TD. 1985. Honey Bee Ecology. Princeton University Press, 216 pp.
23. Snodgrass RE. 1925. Anatomy and Physiology of the Honey Bee. Mc Graw Hill Book Co., New York & London.
24. Snodgrass RE. 1956. Anatomy of the Honey Bee. Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York.

## ENTO 536 SERICULTURE 3 (2+1)

**AIM OF THE COURSE**

To familiarize the students with entrepreneurial opportunities in entomology, sericulture in particular, and providing information on silk worm rearing, production and management.

**COURSE OUTCOME**

1. Students taking up sericulture are expected to have a thorough knowledge of silkworm morphology, races, biology, and all the practices of rearing for silk production.
2. They should be well versed with the pests and diseases of silkworm and their management.
3. With practical training it is expected that students develop entrepreneurial skills for sericulture or link up with industries to sell cocoons for silk production or guide farmers engaged in silk worm rearing/ sericulture.

**THEORY**

**UNIT-I:** History of Sericulture, importance, organizations involved in sericulture activities, silkworm types, distribution, area and silk production.

**UNIT-II:** Mulberry species, ecological requirements, cultivation, improved varieties, propagation methods, sapling production, planting and pruning techniques; pest and diseases, management strategies; intercropping, water and weed management. Food plants of eri silkworm, castor cultivation, intercultural operations, nutrient and water management; method of harvest; host plants of Tasar, nursery and cultivation, selection of seed, soaking and heap making, pruning techniques. Food plants of Muga silkworm, Som and Soalu propagation methods; nursery techniques; intercultural operations and weed management.

**UNIT-III:** Silkworm origin– classification based on voltinism, moultinism, geographical distribution and genetic nature – pure races –multivoltine and bivoltine races– cross breeds – bivoltine hybrids –Races and hybrids of mulberry, eri, tasar and muga silkworm- Morphology and biology of silkworm, sex limited characters; anatomy of digestive and excretory systems of larva; structure and function of silk glands.

**UNIT-IV:** Rearing house, types, disinfection, room and bed disinfectants; egg incubation methods, Chawki rearing, feeding, cleaning and spacing; rearing of late age worms, feeding, cleaning, spacing and moulting care; mountages, cocoon harvesting and marketing; pests and diseases of silkworms and their management.

**UNIT-V:** Post cocoon technology, stifling, cocoon cooking, brushing, reeling, re-reeling, bleaching, degumming, dyeing, printing and weaving, different reeling machines; value addition in sericulture; economics of sericulture.

**PRACTICAL**

- Morphology of mulberry plants;
- Identification of popular mulberry genotypes;

- Nursery bed and main field preparation;
- Planting methods;
- Identification of nutrient deficiency symptoms;
- Identification of weeds;
- Pruning and harvesting methods;
- Identification of pests and diseases of mulberry–*Terminalia arjuna, Terminalia tomentosa,* Som and Soalu- Nursery and pruning techniques – Intercultural operations;
- Morphology of silkworm – Identification of races – Dissection of mouth parts and silk glands – Disinfection techniques – rearing facilities – silkworm rearing – feeding, cleaning and spacing – Identification of pests and diseases of mulberry silkworm – hyperparasitoids and mass multiplication techniques – silkworm egg production technology –Tasar, Eri and muga silkworms – rearing methods–pests and diseases of non-mulberry silkworms – Visit to grainage, cocoon market and silk reeling centre – Economics of silkworm rearing.

**SUGGESTED READINGS**

1. Dandin SB and K Giridhar. 2014. Hand book of Sericulture Technologies. Central Silk Board, Bangalore, 423p.
2. Govindaiah G, VP, Sharma DD, Rajadurai S and Nishita V Naik. 2005. A text book on mulberry crop protection. Central Silk Board, Bangalore.450 p.
3. Jolly MS, Sen SK, Sonwalkar TN and Prasad GK. 1980. Non–mulberry Silks. FAO Agicultural Services Bulletin 29. Food and Agriculture Organization of the United Nations, Rome, 178 p.
4. Mahadevappa D, Halliyal VG, Shankar DG and Ravindra Bhandiwad. 2000. Mulberry Silk Reeling Technology. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi. 234 p.
5. Mohanty PK. 2003. Tropical wild cocoons of India. Daya Publications, Tri Nagar, New Delhi, P197.
6. Nataraju B, Sathyaprasad K, Manjunath D and Kumar A. 2005. Silkworm crop protection.
7. CSB, Bangalore. 412 pp.
8. Rangaswami G, Narasimhanna MN, Kasiviswanathan K, Sastry CR and Jolly MS. 1976. Food Plants of non-mulberry silkworms. In: *Mulberry cultivation*. FAO Agricultural Services Bulletin. Vol.1, Chapter-13. Rome, Italy. 96 p.
9. Tribhuvan Singh and Saratchandra B. 2004. Principles and Techniques of silkworm seed production. Discovery publishing House, New Delhi, 360 pp.

***e-resources***

www.silkwormgenomics.org; www.silkboard.com; ww.silkgermplasm.com; www.csrtimys.res.in

| ENTO 537 | LAC CULTURE | 3 (2+1) |
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**AIM OF THE COURSE**

To familiarize the students with entrepreneurial opportunities in entomology with an emphasis on lac culture in particular. To provide information on lac insect rearing, production and management.

**COURSE OUTCOME**

1. The students are expected to have good knowledge of lac host trees and their maintenance for lac production.
2. It is expected that they should perfect the most suitable techniques for lac production with a good knowledge about diseases and natural enemies of the lac insect.
3. With practical training it is expected that students are able to guide landless labourers, who bring stick lac as forest produce.

**THEORY**

**UNIT-I:** History of lac production; importance, potential of lac production in India; organizations involved in lac production activities; strains of lac insects and lac crops – distribution, area and production of different strains of lac.

**UNIT-II:** Steps and operation of lac production; lac host plant species, ecological requirements, their cultivation; seasons of host plants, harvest time of host plants, rearing seasons; grouping of host trees, pruning methods, timing; lac host plant pests and diseases; management strategies.

**UNIT-III:** Basic morphology and taxonomy of lac insect, strains of lac insect and their characteristics; composition of lac; biology of lac insect, species diversity and distribution.

**UNIT-IV:** Introduction, lac insect-host plant interaction; selection of brood lac, local practices, improved alternatives, coupe system; propagation of lac insects: natural self-inoculation, artificial inoculation; inoculation process and duration; removal of phunki, harvesting of lac, immature harvesting, mature harvesting and time of harvesting. Predators and parasitoids of lac insect, hyperparasites, diseases and their management.

**UNIT-V:** Lac production stages; factors affecting yield and quality of shellac. Pure stock of host plants (kusum, palas, ber, pigeonpea, semialata); alternative method; technology of brood preserving. Host-specific technologies – cultivation on specific host plants; integration of lac cultivation with agro-forestry and horticulture; socio-economic potential of lac; export-import of lac/ lac products; marketing of lac and its products. Lac processing and value addition; entrepreneurship development.

**PRACTICAL**

- Lac host cultivation and lac production practices;
- Equipments for lac production;
- Conventional and advanced methods;
- Coupe system of lac production;
- Cultivation of suitable host plants;
- Pruning of host trees;
- Herbarium of host plants;
- Strains of lac insects;
- Brood lac selection and treatment for pest management;
- Slide preparation of adult and immature stages;
- Inoculation of host tree;
- Identification of natural enemies of lac insect and their management;
- Molecular characterization of lac insect where possible;
- Harvesting;
- Process of manufacture of seed lac, shell lac from stick lac;
- Grading of seed lac and shellac;
- Marketing of lac products and by products.

**SUGGESTED READINGS**

1. David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6$^{th}$ Edition, Namrutha Publications, Chennai.
2. Sharma KK and Ramani S. 2010. *Recent advances in lac culture*. ICAR-IINRG, Ranchi.

## ENTO 538 INSECT VECTORS OF PLANT PATHOGENS 2 (1+1)

**AIM OF THE COURSE**

To teach the students about the different groups of insects that act as vectors of plant pathogens, vector-plant pathogen interaction, and management of vectors for controlling diseases.

**COURSE OUTCOME**

Students are expected to be well versed with insect vectors of plant pathogens, acquire knowledge on disease transmission and vector management techniques.

**THEORY**

**UNIT-I:** History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.

**UNIT-II:** Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.

**UNIT-III:** Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.

**UNIT-IV:** Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.

**UNIT-V:** Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

**PRACTICAL**

- Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes;
- Culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies;
- Vector rearing and maintenance;
- Estimating vector transmission efficiency, studying vector-virus host interaction.

**SUGGESTED READINGS**

1. Basu AN. 1995. Bemisia tabaci (Gennadius) – Crop Pest and Principal Whitefly Vector of Plant Viruses. Oxford and IBH, New Delhi.
2. Harris KF and Maramarosh K. (Eds.). 1980. Vectors of Plant Pathogens. Academic Press, London. Maramorosch K and Harris KF. (Eds.). 1979. Leafhopper Vectors and Plant Disease Agents. Academic Press, London.
3. Youdeovei A and Service MW. 1983. Pest and Vector Management in the Tropics. English Language Books Series, Longman, London.

## ENTO 539 VERTEBRATE PEST MANAGEMENT 2(1+1)

**AIM OF THE COURSE**

To impart knowledge on vertebrate pests like birds, rodents, mammals and others of different crops, their biology, damage they cause and management strategies.

**COURSE OUTCOME**

Students are expected to be well versed with vertebrate pest diversity, their nature of damage, life history traits, behaviour and effective management.

**THEORY**

**UNIT-I:** Introduction to vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals.

**UNIT-II:** Bio-ecology of birds of agricultural importance, patterns of pest damage and assessment, roosting and nesting systems in birds; management of pestiferous birds; conservation of predatory birds.

**UNIT-III:** Bio-ecology of rodents of agricultural importance, patterns of pest damage and assessment, burrowing pattern and habitat of rodents; management of pestiferous rodents.

**UNIT-IV:** Bio-ecology of higher vertebrates of agricultural importance, patterns of damage and assessment, their habitat; management of pestiferous vertebrates.

**UNIT-V:** Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods – Operational practices- baiting, equipments and educative programmes.

**PRACTICAL**

- Identification of important rodents, birds and other vertebrate pests of agriculture, food preference and hoarding;
- Social behaviour, damage assessment, field survey, population estimation, management strategies: preventive and curative methods.

**SUGGESTED READINGS**

1. Ali S. 1965. *The Book of Indian Birds*. The Bombay Natural History Society, Bombay. Fitzwater WD and Prakash I. 1989. *Handbook of Vertebrate Pest Control.* ICAR, New Delhi.
2. Prakash I and Ghosh PK. 1997. *Rodents in Indian Agriculture*. Vol. I. State of Art Scientific Publ., Jodhpur.
3. Prakash I and Ghosh RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.
4. Prater SH. 1971. *The Book of Indian Animals*. The Bombay Natural History Society, Bombay.
5. Rahman A. 2020. *Protective and Productive Entomology* Narendra Publishing House, New Delhi.

## ENTO 540 PLANT QUARANTINE, BIO-SAFETY AND BIO-SECURITY 2 (2+0)

**AIM OF THE COURSE**

To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up. Also to facilitate students to have a good understanding of the aspects of biosafety and biosecurity.

**COURSE OUTCOME**

Students offering this course are expected to have a good knowledge of the rules and regulations of Plant Quarantine, WTO regulations, GAP, Sanitary and Phytosanitary measures.

**THEORY**

**UNIT-I:** Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

**UNIT-II:** Plant protection organization in India. Acts related to registration of pesticides and transgenics. Insecticide regulatory bodies, synthetic insecticides, bio-pesticides and pheromone registration procdures. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

**UNIT-III:** Identification of pest/ disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations; VHT and other safer techniques of disinfestation/ salvaging of infected material.

**UNIT-IV:** WTO regulations; non-tariff barriers; pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; sanitary and phytosanitary measures. Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops.

**SUGGESTED READINGS**

1. Rajeev K and Mukherjee RC. 1996. Role of Plant Quarantine in IPM. Aditya Books.
2. Rhower GG. 1991. Regulatory Plant Pest Management. In: Handbook of Pest Management in Agriculture. 2nd Ed. Vol. II. (Ed. David Pimental), CRC Press.
3. Shukla A and Veda OP. 2007. Introduction to Plant Quarantine. Samay Prakashan, New Delhi.

## ENTO 541 EDIBLE AND THERAPEUTIC INSECTS 2 (1+1)

**AIM OF THE COURSE**

To create awareness and acquaint students about the contribution that insects make to ecosystems, diets, food security and livelihoods in developed and developing countries.

**COURSE OUTCOME**

1. Students are expected to be aware of insects for edible and therapeutic use; their nutritional composition.
2. Should know the techniques of farming and processing insects for human and animal consumption.

**THEORY**

**UNIT-I:** Edible and therapeutic insects: the concept, definition, and importance.

**UNIT-II:** History and origin of insects as food, feed and medication; important insect species and insect products consumed.

**UNIT-III:** Edible insect ecology, conservation and management of edible insect resources; environmental opportunities of insect rearing.

**UNIT-IV:** Nutritional composition and role of insects in food security.

**UNIT-V:** Insect farming: the concept, definitions, and rearing techniques.

**UNIT-VI:** Processing edible insects for food and feed.

**UNIT-VII:** Food safety and preservation, edible insects for livelihood security.

**PRACTICAL**

- Survey and identification of edible and therapeutic insect species;
- Collection and preservation of edible and therapeutic insect specimens;
- Rearing techniques of edible insect species;
- Harvesting techniques of edible insects from natural environment;
- Analysis of proximate elemental composition, antioxidant and anti-nutritional properties and microbial aspects of preservation.

**SUGGESTED READINGS**

1. Halloran A, Flore R, Vantomme P and Roos N 2018. Edible insects in sustainable food systems.
2. Van Huis A, Itterbeeck JK, Klunder H, Mertens E, Halloran A, Muir G and Vantomme. 2013. Edible insects: future prospects for food and feed security. Food and Agricultural Organization of the United Nations, Rome.

## ENTO 542 MEDICAL AND VETERINARY ENTOMOLOGY 2(1+1)

**AIM OF THE COURSE**

To study the major insect, mite, and tick vectors of disease to man and animals. Students will learn to identify and understand the life cycles, morphology, and behaviour of mosquitoes, ticks, mites, lice, fleas, and other disease vectors.

**COURSE OUTCOME**

Students are expected to identify the arthropods of medical and veterinary importance; identify the diseases transmitted by these arthropod vectors and suggest management options.

**THEORY**

**UNIT-I:** Introduction to medical, veterinary and forensic entomology; Classification of Arthropod-borne diseases; Hematophagy, disease transmission and epidemiology; flies (Diptera) of medical and veterinary Importance; moth flies: Leishmaniasis and Bartonellosis; biting midges (*Ceratapogonidae*).

**UNIT-II:** Mosquito taxonomy, biology, and behaviour; mosquito viruses: EEE, VEE, SLE, yellow fever, mosquito surveillance; malaria; horse flies, deer flies: EIA, anaplasmosis; muscid flies; Myiasis (Muscoidea); myiasis and louse flies; black flies of medical and veterinary Importance; filariasis: mansonellosis, onchocerciasis.

**UNIT-III:** Lice of medical and veterinary importance; rickettsial diseases: epidemic typhus, *etc.*; mites: rickettsial pox; mites and acariasis: mange, scabies, chiggers; spiders and scorpions; fleas (Siphonaptera) of medical and veterinary importance; plague and murine typhus.

**UNIT-IV:** Ticks of medical and veterinary importance; lyme disease, rocky mountain spotted fever, tularemia; true bugs (Hemiptera): kissing bugs and bedbugs; chagas disease; tsetse flies; Lepidoptera and Hymenoptera of medical and veterinary importance.

**PRACTICAL**

- Identification of arthropod Classes, Orders and Families of medical and veterinary importance;
- Collection, segregation, curing insect and arachnid specimens, their preservation;
- Management of insect and mite pests of medical and veterinary importance;
- Study of some practical aspects in forensic entomology.

**SUGGESTED READINGS**

1. David BV and Ramamurthy VV. 2011. Elements of Economic Entomology, 6th Edition, Namrutha Publications, Chennai.
2. Gullan PJ and Cranston PS. 2010. The Insects: An Outline of Entomology. 4th Edition, Wiley-Blackwell, West Sussex, UK & New Jersey, US.
3. Mullen G and Durden L. 2018. Medical and Veterinary Entomology, 3rd Edition, Academic Press.

## ENTO 543 FOREST ENTOMOLOGY 2(1+1)

**AIM OF THE COURSE**

To promote a more global theoretical understanding of pest population dynamics and the causes of forest insect outbreaks: covering pests of both natural forests and plantations, the diversity of tropical forest insects, their ecological functions, the concept of pests and the incidence of pests in natural forests, plantations and stored timber.

**COURSE OUTCOME**

1. Students are expected to acquire knowledge of insect pests of forest nurseries, forests and plantations, their nature of damage, life history traits and effective management.
2. Likewise, students are expected to have a thorough knowledge of pestiferous insects of stored timber, hide and other forest produce.

**THEORY**

**UNIT-I:** Introduction to forestry in the tropics, tropical forests: characteristics and types of tropical forests, management of tropical forests and the problems in their management; plantation forestry: beginnings, expansion and current status.

**UNIT-II:** History of tropical forest entomology, diversity of forest insects: structural and functional diversity – the feeding guilds, concept of pests, ecology of insects in forest environment, concept and functioning of ecosystem, role of insects in ecosystem processes of tropical forests: insects as primary consumers, secondary and tertiary consumers, as decomposers, as food, pollinators and other ecological interactions.

**UNIT-III:** Insect pests in natural forests, general pest incidence, pest outbreaks: Lepidoptera, Coleoptera, Hemiptera, and Hymenoptera; insect pests in plantations, nursery pests, sapling pests, pests of older plantations and their impact; insect pests of stored timber, categories of wood destroying insects and their damage: termites and beetles.

**UNIT-IV:** Population dynamics, characteristics of population growth, factors affection population growth, principles governing population dynamics, types and causes of forest insect outbreaks; general issues in forest entomology: enemies' hypothesis, resource concentration hypothesis, pest evolution hypothesis; pest problems in plantations of indigenous *vs.* exotic species; pest problems in monocultures *vs.* mixed plantations.

**UNIT-V:** Management of tropical forest insect pests, historical development and present status of tropical forest pest management, overview of pest management options: preventive measures, remedial measures; unique features of forest pest management; constraints to forest pest management in the tropics; guidelines for the practice of forest pest management in the tropics.

**UNIT-VI:** Insect pests in plantations: Location-specific case studies.

**PRACTICAL**

- Collection, identification and preservation of important insect pest specimens of forest plants and some damage material;
- Detection of insect infestation and assessment of losses due to insect pests;
- Habitat management for vertebrate and insects pests;
- Fire control methods and devices;
- Familiarization with the meteorological and plant protection equipment, application of pesticides and bio-control agents in the management of insect pests in nurseries and plantations.

**SUGGESTED READINGS**


1. Jha LK and Sen Sarna PK. 1994. *Forest Entomology*. Ashish Publishing House, Delhi.
2. Nair KSS. 2007. *Tropical Forest Insect Pests: Ecology, Impact, and Management*, Cambridge University Press, Edinburgh/ New York.
3. Stebbings EP. 1977. *Indian Forest Insects*. JK Jain Brothers.

# COURSE CONTENTS: Ph.D. ENTOMOLOGY

## ENTO 611 INSECT PHYLOGENY AND SYSTEMATICS 3 (1+2)

**OBJECTIVE**

To familiarize the students with different schools of classification, phylogenetics, classical and molecular methods, evolution of different groups of insects. Detailed study about the International Code of Zoological Nomenclature; ethics and procedure for taxonomic publications.

**COURSE OUTCOMES**

1. Scholars are expected to understand the concepts of taxonomic hierarchy, study taxonomic characters, variations, intra-specific phenotypic plasticity; prepare taxonomic keys for specific groups and write taxonomic papers and reviews.
2. Scholars should be able to identify insects of economic importance up to family/ generic levels and specialize in any one group of insects up to species level identification.

**THEORY**

**UNIT-I:** Detailed study of three schools of classification- numerical, evolutionary and cladistic. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts, speciation processes and evidences. Zoogeography.

**UNIT-II:** Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.

**UNIT-III:** Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN; scientific ethics. Nomenclature and documentation protocols and procedures; report preparation on new species; deposition of holotypes, paratypes, and insect specimens as a whole in national and international repositories– requirements and procedures.

**UNIT-IV:** Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, works on revision of taxa, monographs, check lists, faunal volumes, *etc*. Websites related to insect taxonomy and databases. Molecular taxonomy, barcoding species and the progress made in molecular sytematics.

**PRACTICAL**

- Collection, curation and study of one taxon of insects- literature search, compilation of a checklist, study of characters, development of character table, and construction of taxonomic keys for the selected group;
- Development of descriptions, photographing, writing diagrams, and preparation of specimens for "type like" preservation; Submission of the collections made of the group; Multivariate analysis techniques for clustering specimens into different taxa, and development of phenograms; Rooting and character polarization for developing cladograms and use of computer programmes to develop cladograms.

**SUGGESTED READINGS**

1. CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.
2. Dakeshott J and Whitten MA. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer-Verlag, Berlin.
3. Freeman S and Herron JC. 1998. Evolutionary Analysis. Prentice Hall, New Delhi.
4. Hennig W. 1960. Phylogenetic Systematics. Urbana Univ. Illinois Press, USA.
5. Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York.
6. Mayr E and Ashlock PD. 1991. Principles of Systematic Zoology. 2nd Ed. McGraw Hill, New York.
7. Mayr E.1969. Principles of Systematic Zoology. McGraw-Hill, New York.
8. Quicke DLJ. 1993. Principles and Techniques of Contemporary Taxonomy. Blackie Academic and Professional, London.

9. Ross HH. 1974. Biological Systematics. Addison Wesley Publ. Co., London.
10. Wiley EO. 1981. Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists. Columbia Univ. Press, USA.


## ENTO 612 INSECT PHYSIOLOGY AND NUTRITION 3(2+1)

**OBJECTIVE**

To impart knowledge to the students on detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones *etc.*

**COURSE OUTCOMES**

1. The scholars are expected to have thorough theoretical and practical knowledge of insect physiology that can be made use of in practical/ applied entomological aspects.
2. Understand how physiological systems in insects are integrated to maintain homeostasis.

**THEORY**

**UNIT-I:** Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, hardening of cuticlde.

**UNIT-II:** Digestive enzymes, digestive physiology in phytophagous, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development; physiology of excretion and osmoregulation, water conservation mechanisms.

**UNIT-III:** Detailed physiology of nervous system, transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.

**UNIT-IV:** Endocrine system and insect hormones, physiology of insect growth and development-metamorphosis, polymorphism and diapause. Insect behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

**PRACTICAL**

Preparation of synthetic diets for different groups of insects; rearing of insects on synthetic, semisynthetic and natural diets; determination of co-efficient of utilization; qualitative and quantitative profile of bio-molecules: practicing analytical techniques for analysis of free amino acids of haemolymph; zymogram analyses of amylase; determination of chitin in insect cuticle; examination and count of insect haemocytes.

**SUGGESTED READINGS**


1. Ananthkrishnan TN. (Ed.). 1994. Functional Dynamics of Phytophagous Insects. Oxford and IBH, New Delhi.
2. Bernays EA and Chapman RF. 1994. Host-Plant Selection by Phytophagous Insects. Chapman and Hall, London.
3. Kerkut GA and Gilbert LI. 1985. Insect Physiology, Biochemistry and Pharmacology. Vols. I-XIII. Pergamon Press, Oxford, New York.
4. Muraleedharan K. 1997. Recent Advances in Insect Endocrinology. Association for Advancement of Entomology, Trivandrum, Kerala.
5. Rockstein M. 1978. Biochemistry of Insects, Academic Press.
6. Simpson, SJ. 2007. Advances in Insect Physiology, Vol. 33, Academic Press (Elsevier), London, UK.


## ENTO 613 INSECT ECOLOGY AND DIVERSITY 3 (2+1)

**OBJECTIVE**

To impart advanced practical knowledge of causal factors governing the distribution and abundance of insects and the evolution of ecological characteristics. Study insect-plant interactions; get acquainted with biodiversity and conservation.

**COURSE OUTCOMES**

1. The scholar is expected to develop expertise in methods of data collection for insect population studies, data transformation for analyses, diversity estimates, assessing distribution parameters, study the impact of abiotic and biotic factors on the distribution and abundance of insects.
2. Should gain significant knowledge on construction of life tables and their analyses, assessment of resource size by female insects, reproductive effort and fitness.

**THEORY**

**UNIT-I:** Characterization of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics- Life tables, Leslie Matrix, Stable age distribution, Population projections. Predator-Prey Models- Lotka-Volterra and Nicholson-Bailey Model. Crop Modeling- an introduction.

**UNIT-II:** Insect Plant Interactions. Fig-figwasp mutualism and a quantitative view of types of associations. Role of insects in the environment. Adaptations to terrestrial habitats. Evolution of insect diversity and role of phytophagy as an adaptive zone for increased diversity of insects. Evolution of resource harvesting organs, resilience of insect taxa and the sustenance of insect diversity- role of plants. Herbivory, pollination, predation, parasitism. Modes of insect-plant interaction, tri-trophic interactions. Evolution of herbivory, monophagy *vs*. polyphagy. Role of plant secondary metabolites. Meaning of stress- plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defences. Host seeking behaviour of parasitoids.

**UNIT-III:** Biodiversity and Conservation- RET species, Ecological Indicators. Principles of Population genetics, Hardy Weinberg Law, Computation of Allelic and Phenotypic frequencies, Fitness under selection, Rates of Evolution under selection. Foraging Ecology- Optimal foraging theory, Marginal Value Theorem, and Patch departure rules, central place foraging, Mean-variance relationship and foraging by pollinators, Nutritional Ecology.

**UNIT-IV:** Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies – timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict. Agro-ecological vs Natural Ecosystems –Characterisation, Pest Control as applied ecology- case studies.

**PRACTICAL**

- Methods of data collection under field conditions; Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index, Index of Dispersion, *etc*. Calculation of sample sizes by different methods;
- Fitting Poisson and Negative Binomial distributions and working out the data transformation methods; Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies – Calculation of changes under selection;
- Demonstration of genetic drift. Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/Goniozus/Female Bruchids *etc*.- A test of reproductive effort and fitness; Construction of Life tables and application of Leslie Matrix – population projections, Stable age distribution; Exercises in development of Algorithms for crop modeling.

**SUGGESTED READINGS:**

1. Barbosa, P. and Letourneau, D. K. (Eds.). 1988. Novel Aspects of Insect-Plant Interactions. Wiley, London.
2. Elizabeth, B. A and Chapman, R. F. 1994. Host-Plant Selection by Phytophagous Insects. Chapman and Hall, New York.
3. Freeman, S. and Herron, J. C.1998. Evolutionary Analysis. Prentice Hall, New Delhi.
4. Gotelli, N. J and Ellison, A. M. 2004. A Primer of Ecological Statistics. Sinauer Associates.
5. Gotelli, N. J. 2001. A Primer of Ecology. 3rd Ed., Sinauer Associates, Sunderland, MA, USA.
6. Krebs, C. 1998. Ecological Methodology. 2nd Ed. Benjamin-Cummings Publ. Co., New York.
7. Krebs, C.J. 2001 Ecology: The Experimental Analysis of Distribution and Abundance. 5th Ed. Benjamin-Cummings Publ. Co., New York.
8. Magurran, A. E. 1988. Ecological Diversity and its Measurement. Princeton University Press, Princeton.

9. Real, L. A and Brown, J. H. (Eds.). 1991. Foundations of Ecology: Classic Papers with Commentaries. University of Chicago Press, USA.
10. Southwood, T.R.E. and Henderson, P. A. 2000. Ecological Methods. 3rd Ed. Wiley Blackwell, London.
11. Strong DR, Lawton JH and Southwood R. 1984. Insects on Plants: Community Patterns and Mechanism. Harward University Press, Harward.
12. Wratten, S. D and Fry, G. L. A. 1980. Field and Laboratory Exercises in Ecology. Arnold Publ., London.


## ENTO 614 INSECT BEHAVIOUR 2 (1+1)

**OBJECTIVE**

To acquaint the students with a thorough understanding of how natural selection has led to various survival strategies manifested as behaviour in insects.

**COURSE OUTCOMES**

1. Scholars are expected to be well versed with the behavior and orientation of insects towards exploitation as a tool in IPM.

**THEORY**

**UNIT-I:** Defining Behaviour- Concept of melt, instinct, fixed action patterns, imprinting, complex behaviour, inducted behaviour, learnt behaviour and motivation. History of Ethology- development of behaviourism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; studying behaviour- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behaviour and behavioural polymorphism.

**UNIT-II:** Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.

**UNIT-III:** Reproductive behaviour- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behaviour- kin selection, parental manipulation and mutualism; Self organization and insect behaviour.

**UNIT-IV:** Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behavior, pollination behavior, co-evolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semiochemicals, auditory stimuli and visual signals in pest management.

**PRACTICAL**

- Quantitative methods in sampling behavior; training bees to artificial feeders; sensory adaptation and habituation in a fly or butterfly model, physical cues used in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect (DBM or gram pod borer), colour discrimination in honey bee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees;
- Evaluation of different types of traps against fruit flies with respect to signals; Use of honey bees/*Helicoverpa armigera* to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.

**SUGGESTED READINGS**


1. Ananthkrishnan, T. N. (Ed.). 1994. Functional Dynamics of Phytophagous Insects. Oxford and IBH, New Delhi.
2. Awasthi, V. B. 2001. Principles of Insect Behaviour. Scientific Publ., Jodhpur.
3. Bernays, E. A and Chapman, R. F. 1994. Host-Plant Selection by Phytophagous Insects. Chapman and Hall, London.
4. Brown, L. B. 1999. The Experimental Analysis of Insect Behaviour. Springer, Berlin.
5. Krebs, J. R. and Davies, N. B. 1993. An Introduction to Behavioural Ecology. 3rd Ed. Chapman and Hall, London.
6. Manning, A. and Dawkins MS. 1992. An Introduction to Animal Behaviour. Cambridge University Press, USA.

7. Mathews, R. W. and Mathews, J. R. 1978. Insect Behaviour. A Wiley-InterScience Publ. John Wiley and Sons, New York.

## ENTO 615 PLANT RESISTANCE TO INSECTS 2 (1+1)

**OBJECTIVE**

To familiarize the students with recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.

**COURSE OUTCOMES**

1. Scholars are expected to identify sources of resistance in different crops and varieties; their utilization in resistance breeding programmes involving screening techniques for specific pests.

**THEORY**

**UNIT-I:** Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species - gene pool; insect sources – behaviour in relation to host plant factors.

**UNIT-II:** Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylic acid pathways; effects of induced resistance; exogenous application of elicitors.

**UNIT-III:** Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker-aided selection in resistance breeding.

**UNIT-IV:** Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.

**PRACTICAL**

Understanding mechanisms of resistance for orientation, feeding, oviposition *etc.*, allelochemical bases of insect resistance; macroculturing of test insects like aphids, leaf/plant hoppers, mites and stored grain pests; field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries; determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.

**SUGGESTED READINGS**

1. Panda, N. 1979. Principles of Host Plant Resistance to Insects. Allenheld, Osum and Co., New York.
2. Rosenthal, G. A and Janzen, D. H. (Eds.). 1979. Herbivores – their Interactions with Secondary Plant Metabolites. Vol. I, II. Academic Press, New York.
3. Sadasivam, S. and Thayumanavan, B. 2003. Molecular Host Plant Resistance to Pests. Marcel Dekker, New York.
4. Smith, C. M, Khan Z. R and Pathak, M. D. 1994. Techniques for Evaluating Insect Resistance in Crop Plants. CRC Press, Boca Raton, Florida.

## ENTO 616 ACAROLOGY 2 (1+1)

**OBJECTIVE**

To acquire a good working knowledge of identification of economically important groups of mites up to the species level, a detailed understanding of the newer acaricide molecules and utilization of predators.

**COURSE OUTCOMES**

1. Scholars should be able to identify major mite pests, their management and predatory mites that can be used in biological control. They are also expected to learn the rearing techniques of predatory Phytoseiid mites.

**THEORY**

**UNIT-I:** Comparative morphology of Acari, phylogeny of higher categories in mites, knowledge of commonly occurring orders and families of Acari in India. Diagnostic characteristics of commonly occurring species from families Tetranychidae, Tenuipalpidae, Eriophyidae, Tarsonemidae, Phytoseiidae, Bdellidae, Cunaxidae, Stigmaeidae, Pymotidae, Cheyletidae, Acaridae, Pyroglyphidae, Orthogalumnidae, Argasidae, Ixodidae, Sarcoptidae. Soil mites in India.

**UNIT-II:** Management of economical important species of mites in agriculture, veterinary and public health; storage acarology.

**UNIT-III:** Mites as vectors of plant pathogens; mode of action, structure-activity relationships of different groups of acaricides; problem of pesticide resistance in mites, resurgence of mites.

**UNIT-IV:** Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungiidentification, isolation and utilization.

**PRACTICAL**

Identification of commonly occurring mites up to species, preparation of keys for identification; Collection of specific groups of mites and preparing their identification keys; Rearing phytoseiid mites and studying their role in suppression of spider mites; Management of mite pests of crops using acaricides, phytoseiid predators, fungal pathogens *etc.*

**SUGGESTED READINGS**

1. Evans GO.1992. Principles of Acarology. CABI, London.
2. Gerson H and Smiley RL. 1990. Acarine Bio-control Agents- An Illustrated Key and Manual. Chapman and Hall, New York.
3. Gupta SK. 1985. Handbook of Plant Mites of India. Zoological Survey of India, Calcutta.
4. Krantz GW. 1970. A Manual of Acarology. Oregon State University Book Stores, Corvallis, Oregon.
5. Sadana GL. 1997. False Spider Mites Infesting Crops in India. Kalyani Publ. House, New Delhi.

## ENTO 621 BIO-INPUTS FOR PEST MANAGEMENT 3 (2+1)

**OBJECTIVE**

To appraise the students with advanced techniques in handling of different bio-agents, modern methods of biological control and scope in cropping system-based pest management in agro-ecosystems.

**COURSE OUTCOMES**

1. Scholars are expected to learn the mass multiplication techniques of the more common and economically feasible natural enemies to be exploited under IPM programmes. They should be able to guide entrepreneurs for establishing a viable mass-production unit/insectary.

**THEORY**

**UNIT-I:** Scope of classical biological control and augmentative bio-control; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of bio-agents vis-à-vis target pest populations.

**UNIT-II:** Bio-inputs: mass production of bio-pesticides, mass culturing techniques of bio-agents, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.

**UNIT-III:** Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, large-scale production of bio-control agents, bankable project preparation.

**UNIT-IV:** Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in biocontrol agents for introgressing and for progeny selections, breeding techniques of bio-control agents.

**PRACTICAL**

Mass rearing and release of some commonly occurring indigenous natural enemies; assessment of role of natural enemies in reducing pest populations; testing side effects of pesticides on natural enemies; effect of semiochemicals on natural enemies, breeding of various bio-control agents, performance of efficiency analyses on target pests; project document preparation for establishing a viable mass-production unit/insectary; observation of feeding behavior acts of predatory bugs/ beetles.

**SUGGESTED READINGS**


1. Burges HD and Hussey NW. (Eds.). 1971. Microbial Control of Insects and Mites. Academic Press, London.
2. Coppel HC and James WM. 1977. Biological Insect Pest Suppression. Springer Verlag, Berlin.
3. De Bach P. 1964. Biological Control of Insect Pests and Weeds. Chapman and Hall, London.
4. Dhaliwal, GS and Koul O. 2007. Biopesticides and Pest Management. Kalyani Publ., Delhi.
5. Gerson H and Smiley RL. 1990. Acarine Biocontrol Agents – An Illustrated Key and Manual. Chapman and Hall, New York.
6. Huffakar CB and Messenger PS. 1976. Theory and Practices of Biological Control. Academic Press, London.


## ENTO 622 INSECTICIDE TOXICOLOGY AND RESIDUES 3 (2+1)

**OBJECTIVE**

To acquaint the students with the latest advancements in the field of insecticide toxicology, biochemical and physiological target sites of insecticides, and pesticide resistance mechanisms in insects.

**COURSE OUTCOMES**

Scholars are expected to be well versed with the latest technologies of bioassays, insecticide/ pesticide residue analysis and solving problems associated with insect resistance to insecticides.

**THEORY**

**UNIT-I:** Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. Modes of action of newer insecticide molecules; developments in bio-rational approaches; SPLAT; RNAi technology for pest management.

**UNIT-II:** Biochemical and physiological target sites of insecticides in insects; developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.

**UNIT-III:** Joint action of insecticides; activation, synergism and potentiation.

**UNIT-IV:** Problems associated with pesticide use in agriculture: pesticide resistance; resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.

**UNIT-V:** Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; bound and conjugated residues, effect on soil fertility; insecticide laws and standards, and good agricultural practices.

**PRACTICAL**

Residue sampling, extraction, clean-up and estimation of insecticide residues by various methods; calculations and interpretation of data; biochemical and biological techniques for detection of insecticide resistance in insects; preparation of EC formulation using neem oil.

**SUGGESTED READINGS**


1. Busvine JR. 1971. A Critical Review on the Techniques for Testing Insecticides. CABI, London.
2. Dhaliwal GS and Koul O. 2007. Biopesticides and Pest Management. Kalyani Publ., New Delhi.
3. Hayes WJ and Laws ER. 1991. Handbook of Pesticide Toxicology. Academic Press, New York.
4. Ishaaya I and Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.
5. Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York.
6. O' Brien RD. 1974. Insecticides Action and Metabolism. Academic Press, New York.

7. Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi.
8. Prakash A and Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publ., New York.

## ENTO 623 MOLECULAR ENTOMOLOGY 2 (1+1)

**OBJECTIVE**

To familiarize the students with DNA recombinant technology, marker genes, transgenic plants, and biotechnological advances in sericulture & apiculture.

**COURSE OUTCOMES**

1. The scholars are expected to have mastered the molecular techniques applicable in entomological research like isolation of insect DNA, purification, DNA barcoding and utilizing these techniques in molecular systematics and biological control aspects.

**THEORY**

**UNIT-I:** Introduction to molecular biology; techniques used in molecular biology.

**UNIT-II:** DNA and RNA analysis in insects- transcription and translocation mechanisms. DNA recombinant technology, identification of genes/nucleotide sequences for characters of interest. Genetic improvement of natural enemies. Cell lines, genetic engineering in baculoviruses, Bt and entomopathogenic fungi.

**UNIT-III:** Genes of interest in entomological research- marker genes for sex identification, neuropeptides, JH esterase, St-toxins and venoms, chitinase, CPTI; lectins and proteases. Transgenic plants for pest resistance and diseases.

**UNIT-IV:** Insect gene transformation; biotechnology in relation to silkworms and honey bees; introduction of lectin genes for pest suppression; DNA finger printing for taxonomy and phylogeny. Genetic improvement of inebriate tolerance of natural enemies.

**UNIT-V:** DNA-based diagnostics; insect immune systems in comparison to vertebrates; molecular basis of metamorphosis; Sf transgenic technology and implications; molecular biology of baculoviruses; insecticide resistance. Resistance management strategies in transgenic crops.

**PRACTICAL**

Isolation of DNA/RNA; purity determinations, purification of total DNA from animal tissues; base pair estimation; agarose gel electrophoresis; quantitative enzyme profile of alimentary canal; restriction mapping of DNA; demonstration of PCR, RFLP and RAPD techniques.

**SUGGESTED READINGS**

1. Bhattacharya, T. K., Kumar, P. and Sharma, A. 2007. Animal Biotechnology. 1st Ed., Kalyani Publication, New Delhi.
2. Hagedon, H. H, Hilderbrand, J. G, Kidwell, M. G and Law, J. H. 1990. Molecular Insect Science. Plenum Press, New York.
3. Hoy, M. A. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York.
4. Oakeshott, J. and Whitten, M. A. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer Verlag.
5. Rechcigl, J. E. and Rechcigl, N. A. 1998. Biological and Biotechnological Control of Insect Pests. Lewis Publ., North Carolina.
6. Roy, U. and Saxena, V. 2007. A Hand Book of Genetic Engineering. 1st Ed., Kalyani Publ., New Delhi.
7. Singh, B. D. 2008. Biotechnology (Expanding Horizons). Kalyani Publ., New Delhi.
8. Singh, P. 2007. Introductory to Biotechnology. 2nd Ed. Kalyani Publ., New Delhi.

## ENTO 624 INTEGRATED PEST MANAGEMENT 2(2+0)

**OBJECTIVE**

To acquaint the students with recent concepts of integrated pest management; surveillance and data base management; successful national and international case histories of integrated pest management, nonconventional tools in pest management.

**COURSE OUTCOMES**

1. Having gained sufficient experience in advanced studies of IPM the scholars should be able to independently frame IPM schedules for major crops/ cropping ecosystems (cereal/ pulse crop/ oilseed crop based/ vegetable crop based agro-ecosystems).

**THEORY**

**UNIT-I:** Principles of sampling and surveillance, database management and computer programming; simulation techniques, system analysis and modeling.

**UNIT-II:** Study of case histories of national and international programmes, their implementation, adoption and criticism; global trade and risk of invasive pests; updating knowledge on insect outbreaks and their management.

**UNIT-III:** Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes; application of IPM to farmers' real time situation.

**UNIT-IV:** Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

**SUGGESTED READINGS**

1. Dhaliwal, G. S. and Arora, R. 2003. Integrated Pest Management – Concepts and Approaches. Kalyani Publ., New Delhi.
2. Dhaliwal, G. S, Singh R and Chhillar BS. 2006. Essentials of Agricultural Entomology. Kalyani Publ., New Delhi.
3. Flint, M. C. and Bosch, R. V. 1981. Introduction to Integrated Pest Management. Springer, Berlin.
4. Koul, O. and Cuperus, G. W. 2007. Ecologically Based Integrated Pest Management. CABI, London.
5. Koul, O, Dhaliwal GS and Curperus GW. 2004. Integrated Pest Management –Potential, Constraints and Challenges. CABI, London.
6. Maredia, K. M, Dakouo, D. and Mota-Sanchez, D. 2003. Integrated Pest Management in the Global Arena. CABI, London.
7. Metcalf RL and Luckman WH. 1982. Introduction to Insect Pest Management. John Wiley and Sons, New York.
8. Norris, R. F., Caswell-Chen, E. P and Kogan, M. 2002. Concepts in Integrated Pest Management. Prentice Hall, New Delhi.
9. Pedigo, R. L. 1996. Entomology and Pest Management. Prentice Hall, New Delhi.
10. Subramanyam, B. and Hagstrum, D. W. 1995. Integrated Management of Insects in Stored Products. Marcel Dekker, New York.

# DEPARTMENT OF EXTENSION EDUCATION
# AGRICULTURE UNIVERSITY, JODHPUR

**Semester wise Course Title and Credits: M.Sc. (Agri.) Extension Education**

| S.No. | Course No. | Title | Credit Hours |
|---|---|---|---|
| | | **Semester-I** | |
| 1. | EXT 511* | Applied Behaviour Change | 3(2+1) |
| 2. | EXT 512* | Capacity Development | 3(2+1) |
| 3. | EXT 513* | Research Methodology in Extension | 3(2+1) |
| | | **Semester-II** | |
| 4. | EXT 521** | Extension Landscape | 2(2+0) |
| 5. | EXT 522** | ICTs for Agricultural Extension and Advisory Services | 3(2+1) |
| 6. | EXT 523** | Evaluation and Impact Assessment | 3(2+1) |
| | | **Semester-III** | |
| 7 | EXT 531* | Organizational Behaviour and Development | 3(2+1) |
| 8. | EXT 532# | Managing Extension Organisations | 3(2+1) |
| 9. | EXT 533# | Enabling Innovation | 2(1+1) |
| 10. | EXT 534# | Gender Mainstreaming | 3(2+1) |
| 11. | EXT 591** | Master's Seminar | 01 |
| | | **Semester-IV** | |
| 12. | EXT 598** | Comprehensive | Non-Credit |
| 13. | EXT 599** | Thesis/Research | 30 |

* Core Courses–External Examination, ** Compulsory Courses and # Optional Courses (Internal Examination).

**Courses requirement for M.Sc. (Agri.) Extension Education**

| | |
|---|---|
| Core Courses | EXT 511, EXT 512, EXT 513, EXT 531 |
| Compulsory Courses | EXT 521, EXT 522,EXT 523 |
| Optional Courses* | EXT 532, EXT 533, EXT 534 |
| Minor & Supporting Courses* | STAT 512, STAT 522, AGECON 511 |
| Non-credit compulsory Courses | PGS 501, PGS 502, PGS 503, PGS 504 & PGS 505 |
| Seminar | EXT 591 |
| Thesis/Research | EXT 599 |
| Deficiency courses | Nil or as deemed suitable by advisory committee |

*Course as suggested Departmental/ Advisory committee meeting or BOS.

**Semester wise Breakup**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Non-credit compulsory Courses (Credit) | Seminar |
|---|---|---|---|---|---|
| I | 3 (9) | 1 (2) | 1 (3) | 2(2) | - |
| II | 3 (8) | - | 1 (3) | 1 (1) | - |
| III | 1(3) | 2 (6/5) | - | 2(2) | 1 |
| IV | - | - | - | - | - |

**Semester wise Course Title and Credits: Ph.D. Extension Education**

| S.No. | Course No. | Credit hours | Course title |
|---|---|---|---|
| | | | **Semester-I** |
| 1. | EXT 611* | 3(2+1) | Policy Engagement and Extension |
| 2. | EXT 612* | 3(2+1) | Methodologies for Social and Behavioral Sciences |
| 3. | EXT 613** | 3(2+1) | Technology Commercialization and Incubation |
| 4. | EXT 691** | 1(1+0) | Doctor's Seminar |
| | | | **Semester-II** |
| 5. | EXT 621** | 3(2+1) | Educational Technology and Instructional Design |
| 6. | EXT 622# | 3(2+1) | Risk Management and Climate Change Adaptation |
| 7. | EXT 623# | 2(1+1) | Livelihood Development |
| 8. | EXT 624# | 3(2+1) | Facilitation for People Centric Development |
| 9. | EXT 692** | 1(1+0) | Doctor's Seminar |

| Semester-III to Semester –VI | | | |
|---|---|---|---|
| 10. | EXT 698** | NC | Preliminary Exam / Comprehensive |
| 11. | EXT 699** | 75 | Doctors research |

* Core Courses–External Examination ** Compulsory Courses (as per PG/Ph.D. guidelines), # Choose one optional Course out of three

**Course Requirements: Ph. D. Extension Education**

| | |
|---|---|
| Core courses | EXT 611, EXT 612 |
| Compulsory courses | EXT 613, EXT 621 |
| Optional courses | EXT 622, EXT 623, EXT 624 |
| Minor & Supporting Courses* | STAT 513, STAT 523, AGECON 611 or suggested by advisory committee |
| Non-credit compulsory Courses | EXT 698<br>PGS courses** |
| Seminar | EXT 691, EXT 692 |
| Thesis/Research | EXT 699 |
| Deficiency courses | Nil or as deemed suitable by advisory committee |

*Course codes are according to BSMA, subjected change in their respective course committee meeting or BOS. **If not studied during Master's degree programme.

**Semester wise Breakup**

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Non-credit Common compulsory Course (Credit)* | Seminar |
|---|---|---|---|---|---|
| I | 2 (6) | 1(3/2) | 1(3) | 3(3) | 1 |
| II | 2 (6) | 1 (3) | 1 (3/2) | 2(2) | 1 |

*If not studied during Master's degree programme

**Examination Pattern:** M.Sc. (Agri.) Extension Education and Ph.D. Extension Education

| Particulars | Quiz/ Assignment | Mid Term | Final Examination | |
|---|---|---|---|---|
| | | | Theory | Practical |
| Courses with Theory & Practical | 5 | 15 | 50 | 30 |
| Courses comprising only Theory | 5 | 15 | 80 | - |
| Courses comprising only Practical | 5 | 15 | - | 80 |

**Comprehensive Exam Pattern:** Written Exam followed by Oral Exam
**(i) Written Exam:**
M.Sc. (Agri.): 2 papers (1 Major + 1 Supporting & Optional subject)
Ph.D.: 3 papers (2 Major + 1 Supporting & Optional subject)
Maximum marks: 100 each
Paper setting: Internal under the Chairmanship of HOD
Evaluation: Internal under the Chairmanship of HOD
Qualifying marks:
M.Sc. (Agri.): 60% individually
Ph.D.: 65% individually

**(ii) Oral Exam: 100 marks**
M.Sc. (Agri.): After qualifying the Written Exam, the Oral Exam should be conducted by the Students' Advisory Committee in presence of HOD.
Ph.D.: Exam will be conducted by External Examiner
Grading of the Comprehensive Exam (M.Sc. & Ph.D.): Satisfactory/ Not Satisfactory

# COURSE CONTENTS: M.Sc. (Agri.) EXTENSION EDUCATION

**EXT 511 APPLIED BEHAVIOUR CHANGE 3 (2+1)**

**WHY THIS COURSE?**

The behavioral change of the stake holders is the key objective in extension profession, which is reflected through their enhanced capacity, attitude change, modification of perceptions and beliefs, improved understanding of a system, adoption of improved technologies, empowerment, and resilience to adverse phenomenon and improved decision- making. Irrespective of their role and profession, all the key stakeholders in agriculture like farmers, extension agents, scientists/ academicians, development managers and policy makers are human beings, whose behavior is the product of internal psychological processes influenced by external environment. Since human behavior is a psychological phenomenon, expressed through interaction of internal psychological processes, social systems and external environment, there is an essential need to understand how these psychological processes guide the behavioral change. These psychological processes may be expressed at individual, group, community and organizational level involving human learning, choices, judgment and decisions about an extension intervention.

**AIM OF THIS COURSE**

This course aims to build capacities of students to understand the fundamental psychological processes which guide human behaviour at individual, group and community levels in specific contexts, to develop sound extension strategies.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1 | Foundations of Behaviour Change | 1. Foundations of Human Behaviour |
| 2 | Cognitive Processes and Learning | 1. Cognitive Processes affecting human behaviour<br>2. Information Processing<br>3. Learning<br>4. Judgement, Choice and Decision-making |
| 3 | Human Behaviour in the Society | 1. Attitudes and Influence<br>2. Social Judgement, Social Identity and Inter-Group Relations |

**COURSE OUTCOMES:** The students should-

1. Understand the biological and cognitive processes determining human behavior.
2. Understand the process of learning under different context.
3. Develop competencies in influencing the human decision process in various contexts.
4. Design effective strategies to influence attitude and behavior.

**THEORY**

**BLOCK 1: FOUNDATIONS OF BEHAVIOUR CHANGE**

**UNIT-1: Foundations of Human Behaviour**

**Human behaviour**– Meaning, importance and factors influencing human behaviour; **Individual variations** – intelligence, ability and creativity– foundations and theories, personality and temperament - foundations, approaches, theories of personality, measuring personality (traits, locus of control, self-efficacy; **Personal, social and moral development** – meaning, concepts– self-concept, self-esteem and self-worth and theories. **Motivation**– foundations, approaches, theories, managing human needs and motivations; perceiving **others**– impression, attitude, opinions; **Emotions**- foundations, types and functions, measuring emotional intelligence

**BLOCK 2: COGNITIVE PROCESSES AND LEARNING**

**UNIT-1: Cognitive Processes affecting Human Behaviour**

Sensory organs and their role cognition; Cognitive processes – Attention, perception, remembering and forgetting, knowledge and expertise– foundations and theories; Principles and processes of perception; Consciousness– meaning, types, sleep and dreams; Learning and Memory– Memory - meaning, types and mechanisms of storage and retrieval of memories in the Human brain; Complex cognitive processes- Concept formation, Thinking, Problem solving and transfer– foundations, theories and approaches.

**UNIT-2: Information Processing**

**Information processing**– meaning, principles; **Models of information processing**- Waugh and Norman model of primary and secondary memory; Atkinson and Shiffrin's stage model of memory; other models including blooms taxonomy and Sternberg's Information Processing Approach; **Attention and perception**– meaning, types, theories and models; Consciousness

**UNIT-3: Learning**

**Learning**– foundations, approaches and theories; Cognitive approaches of learning– meaning, principles theories and models; Memory– foundations, types; Behavioural approaches of learning– foundations and theories- classical conditioning, operant conditioning, applied behaviour analysis; Social cognitive and constructivist approaches to learning– foundations and theories– social cognitive theory, Self-regulated learning; learning styles– meaning, types and applications in learning

**UNIT-4: Judgment, Choice and Decision-making**

**Human Judgment**– meaning, nature, randomness of situations, theories and models; Choice – meaning, criteria for evaluating options; theories and models of human choice; Choice architecture; **Decision-making–** Meaning, problem analysis; steps and techniques of decision-making under different contexts

**BLOCK 3: HUMAN BEHAVIOUR IN THE SOCIETY**

**UNIT-1: Attitudes and Influence**

**Attitudes**- meaning, assumptions, types, theories and models of attitude formation; methods of changing attitudes, Relating to others- liking, attraction, helping behaviour, prejudice, discrimination and aggression; **Liking/ affect**– meaning, types and theories; **Attraction**– meaning, types and theories; **Persuasion**– meaning, theories and techniques; **Social influence and groups**– conformity, compliance and obedience

**UNIT-2: Social Judgment, Social Identity and Inter-Group Relations**

**Social judgment**– meaning, frame of reference, stereotyping; The judgement of attitude models; **Attribution**– meaning, theories; Rational decision making; **Social identify**– meaning, types; assessment; **Groups** – meaning, types, group processes; sustainability of groups; Inter group processes and theories social learning

**PRACTICAL**

1. Understanding perception– Attentional Blink and Repetition Blindness exercise
2. Understanding attention- Testing selective attention capacity and skills and processing speed ability through Stroop test.
3. Hands-on experience in the techniques for assessing creative thinking– divergent and convergent thinking
4. Lab exercise in applying Maslow's need hierarchy to assess motivation
5. Learning- Classical conditioning and operant conditioning
6. Assessing learning styles through Barsch and Kolb inventories
7. Practical experience in building self-esteem
8. Assessment of emotional intelligence
9. Exercises in problem solving
10. Exercises in visual perception
11. Measuring self-concept using psychometric tools
12. Experiment on factors influencing information processing
13. Assessment of attitudes
14. Hands on experience in methods of persuasion
15. Field experience in assessing social judgement
16. Simulation exercise to understand decision-making under different situations
17. Exercise in rational decision-making.

**TEACHING METHODS/ACTIVITIES**

- Lecture cum discussion
- Class exercises
- Group Presentation

**SUGGESTED READINGS**


1. Eiser J, Richard. 2011. Social Psychology: Attitudes, Cognition and Social Behaviour. Cambridge: Cambridge University Press. (First Edition, 1986))
2. Eysenck MW and Keane M T. 2010.Cognitive psychology: A student's handbook. Sixth Edition, Hove: Psychology Press.
3. Feldman RS. 2008. Essentials of understanding psychology (7th ed.). Boston: McGraw- Hill.
4. Gilovich T, Keltner D, and Nisbett RE. 2011. Social psychology. New York: W.W. Norton & Co.
5. Moreno R. 2010.Educational Psychology. Hoboken, NJ: John Wiley & Sons Inc.
6. Nevid JS. 2012. Essentials of psychology: Concepts and applications Belmont, CA: Wadsworth, Cengage Learning.
7. Rachlin H. 1989. Judgment, decision, and choice: A cognitive/ behavioral synthesis. New York: W.H. Freeman.


## EXT 512 CAPACITY DEVELOPMENT 3 (2+1)

**WHY THIS COURSE?**

Competent and skilful extension professionals are not naturally born. Their capacities need to be improved primarily at three different levels:

1. Pre-service capacity development-Under graduation and post-graduation studies
2. Induction capacity development - Just before job entry
3. In-service capacity development- During job

If undergone appropriately, pre-service studies help extension professionals to mainly acquire knowledge related to development. However, they are not fully ready for development work with required attitude and skills needed by an organization. Properly planned and organized induction/ in-service capacity building programmes help them to use development concepts, apply methods, exhibit attitude and skills required for development work at different levels. In short, the essence of this course is to make you understand these notions and help you to think up, manage, put into practice and evaluate capacity development programmes.

**AIM OF THIS COURSE**

1. To understand the concepts of training, capacity building, capacity development and human resource development in the context of roles and responsibilities of extension professionals.
2. To discuss capacity development- approaches, strategies, needs assessment and methods/ tolls.
3. To help you devise, organize, implement and evaluate capacity development programmes.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1 | Introduction to Capacity Development | 1. Capacity Development - An Overview<br>2. Capacity Development - Approaches and Strategies<br>3. Planning and Organization of Capacity Development Programmes |
| 2 | Capacity Development Needs Assessment | 1. Concept of Need Assessment; Approaches in Need Analysis<br>2. Capacity Development Needs Assessment Methods |
| 3 | Capacity Development Institutions and Management | 1. Capacity Development Institutions<br>2. Capacity Development project formuation |
| 4 | Capacity Development Process and HRD | 1. Capacity Development methods and tools<br>2. Human Resource Development<br>3. Participatory Methods for Technology development and transfer |

**COURSE OUTCOMES:** After successful completion of this course, the students are expected to be able to:

1. Differentiate between training, capacity building, capacity development and human resource development.
2. Explain different levels of capacities, needs assessment approaches & methods, capacity development methods & tools.

3. Formulate, implement and evaluate need based capacity development programmes.

**THEORY**

**BLOCK 1: INTRODUCTION TO CAPACITY DEVELOPMENT**

**UNIT-1: Capacity Development- An Overview**

Training, capacity building, capacity development and HRD-Meaning and differences; Need and principles of capacity development; Types and levels of capacities - Institutional capacities (include the rules, regulations and practices that set the overarching contextual environment), Organisational capacities (how various actors come together to perform given tasks), Individual capacities (technical, functional and leadership skills). Types of capacity building - Based on structure (structured, semi-structured & unstructured), Based on context (orientation, induction and refresher), and other categories (online, Webinar, distance *etc*.). Components of capacity development; Capacity development cycle.

**UNIT-2: Capacity Development- Approaches and Strategies**

**Capacity Development Dilemma-** Theory versus Practice, Trainee versus Task, Structured versus Unstructured, Generic and Specific; **Approaches in Capacity Development-** Informative approach, Participatory approach, Experimental approach/ Experiential, Performance based approach; **Capacity Development Strategies-** Academic strategy, Laboratory strategy, Activity strategy, Action strategy, Personal development strategy, Organizational development strategy.

**UNIT-3: Planning and Organization of Capacity Development Programmes**

**Steps in Designing and Planning of Capacity Development-** Step 1. Select the participants, Step 2. Determine the participants' needs, Step 3. Formulate goal and objectives, Step 4. Outline the content, Step 5. Develop instructional activities, Step 6. Prepare the design, Step7. Prepare evaluation form, Step 8. Determine follow-up activities; **Organising capacity development programme; Operational arrangements at different stages-** Before the programme, During the programme, Middle of the programme, At the end of the programme, After the programme, Follow up; Stakeholders' responsibilities.

**BLOCK 2: CAPACITY DEVELOPMENT NEEDS ASSESSMENT**

**UNIT-1: Concept of Need Assessment; Approaches in Need Analysis**

Performance Analysis, Task Analysis, Competency Study; Needs Survey.

**UNIT-2: Capacity Development Needs Assessment Methods**

**Data Collection Methods in Identifying Needs-** Rational Methods (Observation, Informal talks, Complaints, Comparison, Analysis of report, Opinion poll, Buzz session, Analysis of the new programme), Empirical Methods (Job analysis, Performance evaluation, Checklist or Questionnaire Method, Tests, Critical Incident Technique, Card Sort Method, Focus Group Discussion, Interview, SWOT Analysis); **Information and Skills required in Need Analysis; Identification of Needs through Task Analysis-** Task identification, Task Analysis, Gap Analysis

**BLOCK 3: CAPACITY DEVELOPMENT INSTITUTIONS AND MANAGEMENT**

**UNIT-1: Capacity Development Institutions**

**Capacity Developer (Trainer)**: Meaning and concept; **Types of Capacity Developers** (regular, *ad-hoc*, part time, guest and consultants); **Roles of Capacity Developer** (explainer, clarifier, supporter, confronter, role model, linker, motivator, translator/interpreter, change agent); **Good Capacity Developer– Qualities, skills and roles** Qualities, Skills (Intrapersonal & Inter personal), Roles (Manager, Strategist, Task Analyst, Media Specialist, Instructional Writer, Marketer, Facilitator, Instructor, Counsellor, Transfer Agent, Evaluator); Capacity Development Centres and Locations; Organisation's Role in Capacity Development.

**UNIT-2: Capacity Development Project Formulation**

**Project Proposal: Concept and Meaning; Steps in Project Formulation-** Review of past proposals, Consulting experts, consultants, and previous organizers, Review past project evaluation reports, Interact with the prospective beneficiaries; Format for Writing Project Proposal (LFA)

**BLOCK 4: CAPACITY DEVELOPMENT PROCESS AND HRD**

**UNIT-1: Capacity Development Methods and Tools**

**Capacity Development Methods** –Lecture, Discussion, Syndicate, Seminars, Conference, Symposium, Role Play, Case study, Programmed Instruction, T-group / Laboratory methods; **Factors Determining Selection of Methods -** Capacity development objectives, subject matter, categories of participants, and the available resources like time, location, budget; **Capacity Development Aids.**

**UNIT-2: Human Resource Development**

HRD: Meaning, Importance and Benefits; Types of HRD Systems & Sub-systems Career system (Manpower planning, Recruitment, Career planning, Succession planning, Retention), Work system (Role analysis, Role efficacy, Performance plan, Performance feedback and guidance, Performance appraisal, Promotion, Job rotation, Reward), Development system (Induction, Training, Job enrichment, Self-learning mechanisms, Potential appraisal, Succession development, Counseling, Mentor system), Self-renewal system (Survey, Action research, Organizational development interventions), Culture system (Vision, mission and goals, Values, Communication, Get together and celebrations, Task force, Small groups); Components of HRD System- Performance Appraisal, Potential Appraisal, Task System, Development System, Socialization System, Governance; Functions of HRD-Organizational Development, Career Development, Capacity Development.

**UNIT-3: Participatory Methods For Technology Development And Transfer**

**Participatory extension** – Importance, key features, principles and process of participatory approaches; Different participatory approaches (RRA, PRA, PLA, AEA, PALM, PAR, PAME, ESRE, FPR) and successful models.

**PRACTICAL**

1. Capacity development needs assessment exercise;
2. Capacity development project formulation exercise;
3. Planning organizing and conducting an extension capacity development programme ;
    - Designing a programme;
    - Writing learning objectives;
    - Developing objectives into curriculum;
    - Training plan;
    - Organizing capacity development workshop ;
    - Evaluation with pre & post training tests.

**TEACHING METHODS/ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group work
- Case Analysis
- Guest Lectures
- Review of training manuals and training evaluation studies
- Short attachments to a nearby training institute.

**SUGGESTED READINGS**

1. ADB. 2009. Training Needs Assessment and Strategic Training Plan.
2. Bentaya GM, and Hoffmann V (Eds). 2011. Rural Extension Volume **3** -Training Concepts and Tools. Margraf Publishers GmbH, Scientific books, Kanalstra Be 21; D-97990, Weikersheim, 191 pp.
3. GFRAS. 2012. The New Extensionist: Roles, Strategies, and Capacities to Strengthen Extension and Advisory Services, Global Forum for Advisory Services.
4. GFRAS. 2015. The New Extensionist: Core Competencies for Individuals, GFRAS Brief 3.
5. Horton D. 2002. Planning, Implementing, and Evaluating Capacity Development .ISNAR Briefing Paper 50.
6. ICAR 2015.Training Policy 2015, Indian Council of Agricultural Research.

7. IISD 2015. Appreciative Inquiry and Community Development. International Institute for Sustainable Development.
8. LENCD 2011. How to assess existing capacity and define capacity needs, Learning Network on Capacity Development.
9. Mittal N, Sulaiman RV and Prasad R M. 2016. Assessing Capacity Needs of Extension and Advisory Services a Guide for Facilitators. Agricultural Extension in South Asia.
10. Mishra DC. 1990. New Directions in Extension Training. Directorate of Extension, Ministry of Agriculture, Govt. of India, New Delhi.
11. SIDA. 2000. Working Paper No. 4. Analysis of Needs for Capacity Development.
12. Swanson BE and Rajalahti R. (2010). Strengthening Agricultural Extension and Advisory Services. A Guide for Facilitators.

## EXT 513 RESEARCH METHODOLOGY IN EXTENSION 3 (2+1)

**WHY THIS COURSE?**

Growth of any discipline is directly proportional to the creation of knowledge in that discipline. Extension research is the backbone of extension discipline. Extension research is a unique social science inquiry where research ideas are gathered from the field problems and put through a systematic cycle of objective investigations that result in significant solutions. Apart from developing theories and models that advance scientific knowledge, extension research should also provide new insights for improving extension policy and practice. As extension is a field oriented discipline seeking to improve the welfare of its stakeholders, the extension professionals require critical competencies in conducting empirical research for developing sound extension models, methods and tools.

**AIM OF THIS COURSE**

This course aimed to create a workforce which has sound fundamental knowledge and critical competencies in planning, conducting and applying behavioural research for developing quality extension models, methods and tools.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1 | Introduction to behavioural research | 1. Nature of Behavioural Research<br>2. The Behavioural Research Process |
| 2 | Steps in behavioural research process | 1. Formulating a Research Problem<br>2. Reviewing the Literature<br>3. Identifying Variables and Hypotheses<br>4. Formulating Research Designs, Methods and Tools<br>5. Selecting Sample<br>6. Collecting Data<br>7. Analyzing and Interpreting the Data<br>8. Reporting and Evaluating Research |

**COURSE OUTCOMES**

1. Understand the concepts, paradigms, approaches and strategies of behavioural research.
2. Enable to choose research design, methods and tools suitable for the research problem.
3. Design research instruments skillfully and conduct research in an objective and unbiased way.
4. Analyze the data through appropriate analytical methods and tools and derive meaningful interpretations.

**THEORY**

**BLOCK 1: INTRODUCTION TO BEHAVIOURAL RESEARCH**

**UNIT-1: Nature of Behavioural Research**

**Methods of knowing**; Science and scientific method; **Behavioural research** – Concept, aim, goals and objectives; Characteristics and Paradigms of research; Types of behavioural research based on applications, objectives and inquiry; **Types of knowledge generated through research** – historical, axiological, theoretical and conceptual knowledge, prior research studies, reviews and academic debate; Role of behavioural research in extension; Careers in behavioural research.

**UNIT-2: The Behavioural Research Process**

**Basic steps in behavioural research**– Formulating a Research Problem; Reviewing the Literature; Identifying the variables and hypotheses; Formulating research designs, methods and tools; Selecting sample; Collecting data; Analyzing and Interpreting the Data; Reporting and Evaluating Research; Skills needed to design and conduct research; Writing research proposals.

**BLOCK 2: STEPS IN BEHAVIOURAL RESEARCH PROCESS**

**UNIT-1: Formulating a Research Problem**

**The research problem and research topic**- definitions; Importance of formulating a research problem; Sources of research problems; Characteristics of a good research problem; Research problems in quantitative and qualitative research; Steps in formulating a research problem; Strategies for writing research problem statement; Research purpose statement; **Research questions**– Types, Criteria for selecting research questions, techniques for narrowing a problem into a research question; **Objectives -** Meaning, types and criteria for judging the objectives.

**UNIT-2: Reviewing the Literature**

**Review**-meaning and importance; Types of literature review – Context, Historical, Integrative, methodological, self-study and theoretical; Literature review for quantitative and qualitative studies; **Steps in conducting literature review**– Identify key terms, locate literature, critical evaluation and selection; organizing literature and writing literature review.

**UNIT-3: Identifying Variables and Hypotheses**

**Developing theoretical, conceptual, empirical frameworks**; Approaches for identifying concepts, constructs and variables; Role of theory in behavioural research; **Steps in identifying variables**– Domain, Concepts, Constructs, Dimensions; Indicators; Variables, Definitions, premises, propositions and hypotheses; **Techniques of identifying concepts, constructs and variables**- Types of concepts; Types of variables– causal relationship, the study design; and the unit of measurement; **Types of definitions**-Types of propositions and hypotheses. Characteristics of good hypotheses; **Measurement–** Meaning, levels of measurement– nominal, ordinal, interval and ratio; Criteria for choosing measurement levels for variables.

**UNIT-4: Formulating Research Designs, Methods and Tools**

**Research designs**– Definition, purpose and functions; Research Design as Variance Control MAXMINCON Principle; Criteria for selecting a suitable Research Design; Classification of research designs: Quantitative designs- experimental, descriptive, comparative, correlational, survey, ex-post facto and secondary data analysis; **Qualitative designs**- ethnographic, grounded theory, phenomenological and Narrative research; **Mixed method designs–** Action research design; Translational research; **Elements of research design**- Research strategies, Extent of researcher interference, Study setting, unit of analysis and Time horizon. Sources of errors while specifying research designs. Internal and external validity; Choosing right research design; **Triangulation-** Importance in behavioural research, Types of triangulation. **Research methods:** Designing research Instruments– questionnaires, interview schedules; tests- knowledge tests, behaviour performance tests; scales– scales and indexes, checklists, focus groups; Steps in developing and using research methods and tools; participatory rural appraisal.

**UNIT-5: Selecting Sample**

**Sampling**- population, element, sample, sampling unit, and subject; Sampling strategies for quantitative and qualitative research; Principles of sampling; Factors affecting the inferences drawn from a sample; Types of sampling, Methods of drawing a random sample, Sampling with or without replacement, **Types of sampling**- Probability Sampling- Simple random sampling, Cluster sampling, Systematic sampling, Stratified random sampling and Unequal probability Sampling; **Non-probability Sampling**- Reliance of available subjects, Purposive or judgmental sampling, accidental sampling, expert sampling, Snowball sampling, and Quota sampling; Sample size requirements for quantitative and qualitative studies. Methods for estimating sample size; **Generalization**– Importance, Types of generalizations.

**UNIT-6: Collecting Data**

**The process of collecting data–** Selection, training, supervision, and evaluation of field investigators; Online data collection; Errors and biases during data collection. Testing goodness of measures through item analysis - Reliability and validity; **Types of validity –** Content validity:

Face and content validity, Criterion-related validity: concurrent and predictive validity, Construct validity: convergent, and discriminant validity, factorial validity and nomological validity; **Types of reliability**– Test-Retest, Parallel forms, Inter- item consistency reliability, Split-half reliability. Factors affecting the validity and reliability of research instruments, Strategies for enhancing validity and reliability of measures. Validity and reliability in qualitative research

**UNIT-7: Analyzing and Interpreting the Data**

Data coding, exploration and editing; Methods of data processing in quantitative and qualitative studies; **Quantitative data analysis**- parametric and non-parametric statistical analyses; **Parametric analysis**– Descriptive and inferential statistics, **Hypothesis testing**- Type I and Type II errors. **Concepts in hypothesis testing**- Effect Size, α, β, and Power, P Value; **Multivariate data analysis**– regression, factor analysis, cluster analysis, logistic regression and structural equation modeling. Guidelines for choosing appropriate statistical analysis; Statistical packages for data analysis; **Methods of interpreting data and drawing inferences**- The Ladder of Inference; Methods of communicating and displaying analysed data.

**UNIT-8: Reporting and Evaluating Research**

Writing reports and research publications; Evaluation Methodology.

**PRACTICAL**

1. Selecting a research problem and writing problem statement;
2. Narrowing down research problem to purpose, research questions and objectives;
3. Choosing, evaluating and reviewing research literature;
4. Selection of variables through construct conceptualization and defining variables;
5. Choosing research design based on research problem;
6. Choosing right sampling method and estimating sample size;
7. Developing research methods and tools – questionnaires, interview schedule, check lists and focus group guides;
8. Writing a research proposal;
9. Field data collection using research methods and tools;
10. Testing reliability and validity of research instruments;
11. Hands on experience in using SPSS for coding, data exploration, editing, analysis and interpretation Formulation of secondary tables based on objectives of research;
12. Writing report, writing of thesis and research articles;
13. Presentation of reports.

**TEACHING METHODS/ACTIVITIES**

- Lecture cum discussion
- Class exercises
- Assignment(Reading/Writing)
- Student's Book/Publication Review
- Student presentation
- Group Work
- Research Report

**SUGGESTED READINGS:**


1. Babbie E. 2008. The basics of social research. $4^{th}$ ed. Belmont, CA, USA; Thompson Wordsworth.
2. Creswell JW. 2009. Research design: Qualitative, quantitative, and mixed methods approaches. Third edition. Thousand Oaks: Sage Publications.
3. Creswell JW. 2012. Educational research: Planning, conducting, and evaluating quantitative and qualitative research. Fourth edition. Boston, MA: Pearson.
4. Kerlinger FN and Lee HB. 2000. Foundations of Behavioral Research. Orlando, FL: Harcourt College Publishers.
5. Kumar R. 2014. Research Methodology: A Step-by-Step Guide for Beginners. Fourth Edition. Thousand Oaks, California: Sage Publications.
6. Malhotra NK. 2010. Marketing research: An applied orientation. Sixth Edition. Upper Saddle River, NJ: Prentice Hall.

7. Neuman WL. 2006. Social Research Methods: Qualitative and Quantitative Approaches. Toronto: Pearson.
8. Sekaran U and Bougie R. 2013.Research Methods for Business A Skill-Building Approach. 6th Edition, Wiley, New York.
9. Sendhil R, Kumar A, Singh S, Verma A, Venkatesh K and Gupta V. 2017. Data Analysis Tools and Approaches (DATA) in Agricultural Sciences. e-Compendium of Training-cum-Workshop organised at the ICAR-IIWBR during March 22-24, 2017. pp 1-126.
10. Sivakumar PS, Sontakki BS, Sulaiman RV, Saravanan R and Mittal N. (eds). 2017. Good Practices in Agricultural extension Research. Manual on Good Practices in Extension Research and Evaluation. Agricultural Extension in South Asia. Centre for research on innovation and science and policy (CRISP), Hyderabad. India.
11. Sivakumar PS and Sulaiman RV. 2015. Extension Research in India-Current Status and Future Strategies. AESA Working Paper 2. Agricultural Extension in South Asia.

## EXT 521 EXTENSION LANDSCAPE 2 (2+0)

**WHY THIS COURSE?**

Extension and advisory services (EAS) need to support farmers to deal with several new challenges they face currently. To effectively support farmers, EAS should perform several new functions and it should have capacities to perform these functions. EAS have evolved considerably especially during the last 3 decades. Several new approaches have emerged and many new funding and delivery models emerged in response to reforms (economic policies and new governance structure) implemented in several countries. Apart from these, new insights from communication and innovation studies have also started to influence the practice of extension. There is a lot of interest globally in strengthening pluralistic EAS and enhancing its contribution towards development of an effective Agricultural Innovation System (AIS). Keeping these in view, there is a need to orient students of extension on how extension is shaped globally and the policy level challenges it faces so that the extension students fit well to the global demand for competent extension professionals who can appreciate and understand this changing context.

**AIM OF THIS COURSE**

The aim of this course is to introduce the new challenges before extension and how extension is evolving globally. It presents the new capacities that are needed by EAS providers to provide a much wider support to farmers and it orient students to the new insights from communication and innovation studies that are influencing the practice of extension globally. The course also help students to appreciate the process and the impact of extension reforms implemented in many countries, the new approaches that are evolving globally in different regions and the policy challenges in managing a pluralistic extension system.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1 | Globally, What is new in Extension? | 1.Challenges Before Extension and Advisory Services<br>2. New Functions and New Capacities<br>3. Pluralism in EAS |
| 2 | Insights from Communication & Innovation Studies & New Extension Approaches | 1. From the Linear Paradigm To Systems Paradigm<br>2. Evolving Extension Approaches |
| 3 | Extension Reforms And Policy Challenges | 1. Changes In Governance, Funding and Delivery of EAS<br>2. Challenges In Managing Pluralistic Extension Systems |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Appreciate the changing global extension landscape.
2. Broaden their understanding on the role of EAS in agricultural innovation system.
3. Critically evaluate the reforms in extension and the evolving approaches in extension.
4. Analyze the policy level challenges in extension funding and delivery.

**THEORY**

**BLOCK 1: GLOBALLY, WHAT IS NEW IN EXTENSION?**

**UNIT-1: Challenges before Extension and Advisory Services (EAS)**

**Extension and Advisory Services (EAS)**- Meaning (embracing pluralism and new functions) New Challenges before farmers and extension professionals**: Natural Resource Management**-Supporting farmers to manage the declining/deteriorating water and soil for farming; **Gender Mainstreaming-** How extension can enhance access to new knowledge among women farmers; **Nutrition-** Role of extension in supporting communities with growing nutritious crop and eating healthy food; **Linking farmers to markets**- Value chain extension including organizing farmers, strengthen value chain and supporting farmers to respond to new standards and regulations in agri-food systems; **Adaptation to climate changes**- How extension can contribute to up-scaling Climate Smart Agriculture; **Supporting family farms**- strengthening the capacities of family farms; **Migration**-Advising farmers to better respond to opportunities that emerge from increasing mobility and also supporting migrants in enhancing their knowledge and skills; Attracting and Retaining Youth in Agriculture including promotion of agripreneurship and agri-tourism; **Urban and peri-urban farming-** How to support and address issues associated with urban and peri-urban agriculture; **Farmer distress, suicides-** Supporting farmers in tackling farm distress

**UNIT-2: New Functions and New Capacities**

**Beyond transfer of technology**: Performing new functions to deal with new challenges; **Organising producers into groups-**dealing with problems that need collective decision making such as Natural Resource Management (NRM) and access to markets; Mediating conflicts and building consensus to strengthen collective decision making**; Facilitating access to credit, inputs and services**-including development of service providers; Influencing policies to promote new knowledge at a scale Networking and partnership development including convening multi-stakeholder platforms/ innovation platforms.

New Capacities needed by extension and advisory services at different levels at the individual (lower, middle management and senior management levels), organizational and enabling environment levels; Core competencies at the individual level; Varied mechanisms for capacity development (beyond training).

**UNIT-3: Pluralism in EAS**

**Pluralism in Extension Delivery**: Role of private sector (input firms, agri-business companies, consultant firms and individual consultants)- Trends in the development of private extension and advisory services in India and other countries; challenges faced by private extension providers; Role of Non-Governmental Organizations (National/ International)/ Civil Society Organizations (CSOs) in providing extension- Experiences from India and other countries; **Producer Organizations**- Role in strengthening demand and supply of extension services; their strength and weaknesses-experiences from different sectors; Role of Media and ICT advisory service providers; global experiences with use of media and ICTs in advisory services provision.

**BLOCK 2: INSIGHTS FROM INNOVATION STUDIES AND NEW EXTENSION APPROACHES**

**UNIT-1: From the Linear Paradigm to Systems Paradigm**

**Diffusion of Innovations paradigm**- strengths and limitations**; Multiple sources of innovation-** farmer innovation, institutional innovation; farmer participation in technology generation and promotion; strength and limitations; Agricultural Knowledge and Information Systems (AKIS); strength and limitations**; Agricultural Innovation Systems (AIS);** Redefining Innovation- Role of Extension and Advisory Services in AIS-From information delivery to intermediation across multiple nodes; Role of brokering; Innovation Platforms, Innovation Management; Strength and weaknesses of AIS. **Rethinking Communication in the Innovation Process**– Network building, support social learning, dealing with dynamics of power and conflict.

**UNIT-2: Evolving Extension Approaches**

**Evolution and features of extension approaches:** Transfer of technology approach; educational approach, farmer participatory extension approach, demand-driven extension, market led extension (value chain extension)**,** extension for climate smart agriculture, gender sensitive extension, extension for entrepreneurship.

**Extension systems in different regions**: Asia-Pacific, Europe, Latin America, Australia, North America **Networking for Strengthening EAS**: GFRAS (Global Forum for Rural Advisory Services) and its regional networks.

**BLOCK 3: EXTENSION REFORMS AND POLICY CHALLENGES**

**UNIT-1: Changes in Governance, Funding and Delivery of EAS**

**Reduction in public funding:** public withdrawal from extension provision (partial/full); Examples/Cases; Privatization: Public funding and private delivery; cost sharing and cost recovery; Examples/Cases; Decentralisation of extension services; Examples/Cases; Lessons from extension reforms in different countries; Extension and Sustainable Development Goals (SDGs).

**UNIT-2: Challenges in Managing Pluralistic Extension Systems**

**Pluralism:** Managing pluralism and Co-ordination of pluralistic extension provision; Public private partnerships in extension (including the role of local governments/panchayats and producer organisations); Examples, challenges in co-ordination; Achieving convergence in extension planning and delivery, **Financing Extension**: Mobilising resources for extension: public investments, donor support (grants/loans); **Monitoring and Evaluation of Extension**: Generating appropriate data for Assessment and Evaluation of pluralistic extension; **Strengthening extension policy interface**; generating evidence on impact of extension and policy relevant communication.

**TEACHING METHODS/ACTIVITIES**

- Lecture
- Assignment (Reading/ Writing)s
- Book Review by students
- Student presentation
- Group Work

**SUGGESTED READINGS:**

1. Bitzer V, Wongtschowski M, Hani M and Blum M. 2016. New directions for inclusive Pluralistic Service Systems. In New Directions for Inclusive Pluralistic Service Systems Rome (Italy). FAO.
2. Christoplos I. 2010. Mobilizing the potential of rural and agricultural extension. Food and Agriculture Organization of the United Nations. Rome.
3. Colverson KE. 2015. Integrating Gender into Rural Advisory Services. Note 4. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.
4. FAO. 2016. New directions for inclusive Pluralistic Service Systems. Report of FAO Expert Consultation. Food and Agriculture Organization of the United Nations and Royal Tropical Institute, Rome.
5. Faure G, Pautrizel L, de Romémont A, Toillier A, Odru M and Havard M. 2015. Management Advice for Family Farms to Strengthen Entrepreneurial Skills. Note 8. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.
6. Francis J, Mytelka L, Van Huis A and Röling N (eds.). 2016. Innovation Systems: Towards Effective Strategies in support of Smallholder Farmers. Technical Centre for Agricultural and Rural Cooperation (CTA) and Wageningen University and Research (WUR)/Convergence of Sciences Strengthening Innovation Systems (CoS-SIS), Wageningen.
7. GFRAS. 2016. The New Extensionist Learning Kit. http://g-fras.org/en/knowledge/new-extensionist-learningkit-nelk.html#module-1-introduction-to-the-new-extensionist
8. GRFAS. 2014. Policy Compendium. http://www.g-fras.org/en/policy-compendium.html
9. Gwyn EJ and Garforth C. nd. The history, development, and future of agricultural extension. FAO. Rome. http://www.fao.org/docrep/W5830E/w5830e03.htm
10. Rivera W and Zijp W. 2002. Contracting for Agricultural Extension-International Case Studies and Emerging Practices. CABI Publishing.
11. Saravanan R, Suchiradipta B, Meera SN, Kathiresan C and Anandaraja N. 2015. Web Portals for Agricultural Extension and Advisory Services. Note 16. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.
12. Swanson BE. 2008. Global Review of Good Agricultural Extension and Advisory Service Practices. Food and Agriculture Organization of the United Nations. Rome.
13. Terblanche S and H Ngwenya. 2017. Professionalisation of Rural Advisory Services. Note GFRAS Global Good Practice Notes for Extension and Advisory Services. GFRAS: Lausanne, Switzerland.

14. World Bank. 2006. Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems. Washington, DC: World Bank. © World Bank.

## EXT 522 ICTs FOR AGRICULTURAL EXTENSION AND ADVISORY SERVICES 3 (2+1)

**WHY THIS COURSE?**

Information and Communication Technologies (ICTs) are continuously evolving. More ICT applications having better relevance to extension and advisory services (EAS) are currently available considering the human and other resource constrains faced by EAS, ICTs can supplement and complement EAS extension efforts in a cost-effective way. Extension professionals should have sound knowledge of ICTs and comprehensive understanding on its various applications for effectively deploying these in EAS provision. This course will provide knowledge and hands-on-experience on ICT applications relevant for EAS.

**AIM OF THIS COURSE**

- To discuss different ICT initiatives, knowledge management process and application aspects.
- To orient students on advances in smart/ disruptive technologies and data analytics.
- Hands on experience in navigating ICTs.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Introduction to Information and Communication Technologies (ICTS) & e- Extension | 1.ICTs- Concepts and Status |
| | | 2.ICTs in Knowledge Management |
| | | 3.e-Extension initiatives in Agriculture and allied sectors |
| 2. | Application of ICTs in Extension and advisory services | 1.ICT Applications |
| | | 2.ICT Expert Systems |
| | | 3.ICT Networks |
| 3. | Knowledge management and Standards | 1.Policies in Knowledge Management |
| | | 2.Web Standards |
| | | 3.Social Media Applications to engage audience |
| 4. | Smart & disruptive Technologies and advanced analytics for agricultural extension | 1.Smart Technologies |
| | | 2.Human Computer Interactions |

**COURSE OUTCOMES**

1. After successful completion of this course, the students are expected to be able to: Appreciate the importance of the ICTs in EAS;
2. Understand the ICT application aspects;
3. Critically evaluate ICT initiatives and smart/disruptive technologies;
4. To execute extension functions by applying ICTs and
5. Engage stakeholders in knowledge management process.

**THEORY**

**BLOCK 1: INTRODUCTION TO INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTS) & E-EXTENSION**

**UNIT-1: ICTs- Concepts and Status**

**ICTs-** meaning, concepts, basics of ICTs, global and national status, types and functions of ICTs, innovations, meaning of e-Governance, *e*-learning, *m*-Learning, advantages and limitations of ICTs

**UNIT-2: ICTs in Knowledge Management**

**Knowledge management**-meaning, approaches and tools. Role of ICTs in Agricultural Knowledge Management.

**UNIT-3: e-Extension initiatives in Agriculture and allied sectors**

**e-Extension, overview on** Global and national **e-extension initiatives, Inventory of e-Extension initiatives in Agriculture and allied sectors from Central and State governments, ICAR, SAUs, private sector and NGO initiatives in India.**

**BLOCK 2: APPLICATION OF ICTS IN EXTENSION AND ADVISORY SERVICES**

**UNIT-1: ICT Applications**

Knowledge centers (tele centers), digital kiosks, websites and web portals, community radio, farmers call centers, mobile phone based advisory services and mobile applications (mExtension, mLearning), Self-learning CDs on Package of practices, social media, digital videos, **Market Intelligence and Information Systems-** ICT enabled Supply-Chains & Value-Chains/ e-Marketing (e-NAM, Agmarknet *etc*.).

**UNIT-2: ICT Expert Systems**

Expert System/ Decision Support System/ Management Information Systems, Farm Health Management & Intelligence System for Plant Health, Animal Health, Soil Health, Fishery, Water, Weather, *etc*.

**UNIT-3: ICT Networks**

**Global and regional knowledge networks**, international information management systems, e-Learning platforms (MOOCS, Course CERA, Edu. Ex, *etc*), e-Governance Systems; digital networks among extension personnel, Farmer Producers Organizations (FPOs)/ SHGs/ Farmers Groups.

**BLOCK 3: KNOWLEDGE MANAGEMENT AND STANDARDS**

**UNIT-1: Policies in Knowledge Management**

**Global policy/ Standards** on e-Governance, National policy on e-governance, Open Data / Open Gov Standards and Open Source *etc*; Language Technology Applications; National e-Agriculture policy/ Strategies/ guideline.

**UNIT-2: Web Standards**

Web standards, creating and writing for web portals, development of mobile applications, developing digital videos- story board- video recording- video editing, types of blogs and writing guidelines.

**UNIT-3: Social Media Applications to engage audience**

Video conference, live streaming and webinars, types and functions of social media applications, guidelines for preparing social media content, engaging audience and data- analytics.

**BLOCK 4: SMART & DISRUPTIVE TECHNOLOGIES AND ADVANCED ANALYTICS FOR AGRICULTURAL EXTENSION**

**UNIT-1: Smart Technologies**

Open technology computing facilities, System for data analytics/ mining/ modeling/ Development of Agricultural simulations; Remote Sensing, GIS, GPS, Information Utility (AIU); **Disruptive technologies-** Analysis; Internet of Things (IoTs), Drones, Artificial intelligence (AI), block chain technology, social media and Big Data analytics for extension.

**UNIT-2: Human Computer Interactions**

**Human Centered Learning/Ergonomics/ Human Computer Interactions**-Meaning; Theories of multimedia learning - Sweller's cognitive load theory, Mayer's cognitive theory of multimedia learning, Schnotz's integrative model of text and picture comprehension, van Merriënboer's four-component instructional design model for multimedia learning; **Basic Principles of Multimedia Learning** - Split-attention, Modality, Redundancy, Coherence, Signaling, segmenting, pre-training, personalisation, voice embodiment; **Advanced principles-** Guided discovery, worked examples, Self-explanation, drawing, feedback, multiple representation, Learner control, animation, collaboration, prior knowledge, and working memory. **Designing ICT gadgets based on human interaction principles** - Interactive design-Meaning, importance; **Approaches of interactive design**- user-centered design, activity-centered design, systems design, and genius design; **Methods of interactive design** - Usability testing methods.

**PRACTICAL**

1. Content and client engagement analysis;
2. Designing extension content for ICTs;
3. Creating and designing web portals, blogs, social media pages;
4. Developing digital videos;
5. Live streaming extension programmes and organizing webinars;
6. Working with Farmers call centers;
7. Engaging with professional digital networks;
8. Writing for digital media.

**TEACHING METHODS/ACTIVITIES**

- Lecture
- Guest Lectures
- Assignment (Reading/Writing/developing Apps/ media management/ Social media initiatives)
- Student's Book/Publication Review
- Student presentation
- Group Work
- Student's interview of ICT practitioners/ champions
- Documenting good practices and case studies
- Review of ICT policy documents and guidelines/ standards
- Short internship with ICT projects

**SUGGESTED READINGS**

1. Andres D and Woodard J. 2013. Social media handbook for agricultural development practitioners. Publication by FHI360 of USAID.
2. Bheenick K and Bionyi I. 2017.Effective Tools for Knowledge Management and Learning in Agriculture and Rural Development. CTA Working paper.
3. Fafchamps M and Minten B. 2012. Impact of SMS based Agricultural Information onIndian Farmers.The World Bank Economic Review, Published by the Oxford University Press on behalf of the International Bank for Reconstruction and Development.
4. Meera SN.2013. Extension, ICTs and Knowledge Management: The 10 difficult questions. Blog 15.Agricultural Extension in South Asia.
5. Meera SN.2018. A Treatise on Navigating Extension and Advisory Services through Digital Disruption. Blog 90.Agricultural Extension in South Asia.
6. Mittal N, Surabhi, Gandhi, Sanjay and Gaurav T. 2010.Socio-Economic Impact of Mobile Phones on Indian Agriculture. ICRIER Working Paper No. 246, Indian Council for Research on International Economic Relations (ICRIER), New Delhi. Preece J, Rogers Y, & Preece, J. 2007. Interaction design: Beyond human-computer interaction. Chichester: Wiley.
7. Saravanan R, Suchiradipta B, Meera SN, Kathiresan C and AnandarajaN. 2015. Web Portals for Agricultural Extension and Advisory Services. Note 16. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.
8. Saravanan R, Kathiresan C, and Indra DT. 2011. (Eds.) Information and Communication Technology for Agriculture and Rural Development, New India Publishing Agency (NIPA), New Delhi.
9. Sophie T and Alice VDE. 2018. Gender and ICTs- Mainstreaming gender in the use of information and communication technologies (ICTs) for agriculture and rural development, FAO.
10. Suchiradipta B and Saravanan R. 2016. Social media: Shaping the future of agricultural extension and advisory services, GFRAS interest group on ICT4RAS discussion paper, GFRAS: Lindau, Switzerland.

## EXT 523 EVALUATION AND IMPACT ASSESSMENT 3 (2+1)

**WHY THIS COURSE?**

Many organizations now look for experts to evaluate development projects and developmental interventions. It is now required that impact be assessed whenever any development programme is implemented. Thus, the extension professionals need to have good understanding of the theory and practice of programme evaluation and impact assessment. This course, thus, has been designed to help students develop as extension professionals who can plan and conduct systematic assessments of the results and impacts of extension programmes.

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Programme Evaluation | 1. Introduction to Evaluation |
| | | 2. Evaluation Theories |
| 2. | Evaluation Process | 1. How to Conduct Evaluation |
| | | 2. Evaluating the Evaluation |
| 3. | Programme Management Techniques | 1. SWOT Analysis and Bar Charts |

| | | |
|---|---|---|
| | | 2. Networks |
| 4. | Programme Evaluation Tools | 1. Bennett's Hierarchy of Evaluation |
| | | 2. Logic Framework Approach |
| 5. | Impact Assessment | 1. Introduction to Impact Assessment |
| | | 2. Impact Assessment Indicators |
| | | 3. Approaches to Impact Assessment |
| | | 4. Environment Impact Assessment |

**AIM OF THIS COURSE**

- To orient students on the importance of evaluation and impact assessment
- To develop capacities for evaluation and impact assessment
- Discuss ways of conducting evaluations and impact assessment.

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Develop competencies in the areas of evaluation planning, indicator development, conducting evaluation and impact assessment and writing reports

**THEORY**

**BLOCK 1: PROGRAMME EVALUATION**

**UNIT-1: Introduction to Evaluation**

**Concept of Evaluation:** Meaning and concept in different contexts; **Why Evaluation is Done and When?** Programme planning, analyze programme effectiveness, decision making, accountability, impact assessment, policy advocacy; Objectives, types, criteria and approaches of programme evaluation, evaluation principles; the context of program evaluation in agricultural extension; **Role and Credibility of Evaluator**: Role as educator, facilitator, consultant, interpreter, mediator and change agent. Competency and credibility of evaluator.

**UNIT-2: Evaluation Theories**

**Evaluation theory vs. practice–** synergistic role between practice and theory in evaluation; **Evaluation theories-** Three broad categories of theories that evaluators use in their works - programme theory, social science theory, and evaluation theory (other theories/ approaches- Utilization-Focused Evaluation & Utilization-Focused Evaluation (U-FE) Checklist, Values Engaged Evaluation, Empowerment Evaluation, Theory-Driven Evaluation). **Integration between theory and practice of evaluation:**– evaluation forums, workshops, conferences and apprenticeship/ internship.

**BLOCK 2: EVALUATION PROCESS**

**UNIT-1: How to Conduct Evaluation**

**Ten Steps in programme evaluation:** (1) Identify and describe programme you want to evaluate (2) Identify the phase of the programme(design, start-up, on-going, wrap-up, follow-up) and type of evaluation study needed (needs assessment, baseline, formative, summative, follow-up) (3) Assess the feasibility of implementing an evaluation (4) Identify and consult key stakeholders (5) Identify approaches to data collection (quantitative, qualitative, mixed) (6) Select data collection techniques (survey interviews and questionnaires with different types) (7) Identify population and select sample (sampling for evaluation, sample size, errors, sampling techniques (8) Collect, analyze and interpret data (qualitative and quantitative evaluation data analysis) (9) Communicate findings (reporting plan, evaluation report types, reporting results, reporting tips, reporting negative findings (10) Apply and use findings (programme continuation/ discontinuation, improve on-going programme, plan future programmes and inform programme stakeholders).

**UNIT-2: Evaluating the Evaluation**

**Evaluating the Evaluation**- 10 Steps as above with focus on conceptual clarity, representation of programme components and stakeholders, sensitivity, representativeness of needs, sample and data, technical adequacy, methods used for data collection and analysis, costs, recommendations and reports.

**BLOCK 3: PROGRAMME MANAGEMENT TECHNIQUES**

**UNIT-1: SWOT Analysis and Bar Charts**

**SWOT Analysis-** Concept, origin and evolution; **SWOT As a Programme Management Tool; Conducting SWOT Analysis**- Common Questions in SWOT Analysis; **Advantages and Disadvantages of SWOT; Bar Charts (**Gantt Charts and Milestone Charts)- Characteristics, advantages and limitations.

**UNIT-2: Networks**

Introduction, origin and widely used networks (Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM), differences between PERT and CPM, advantages and disadvantages. **Networks Terminology–** Activity, Dummy activity, Event (predecessor event, successor event, burst event, merge event, critical event), Earliest Start Time (EST), Latest Start Time (LST), Critical Path, Critical Activity, Optimistic time ($T_O$), Pessimistic time ($P_O$), Most likely time ($T_M$), Expected time ($T_E$), Float or Slack, Event Slack, Lead time, Lag time, Fast tracking, Crashing critical path, Acclivity Table, Danglers, Normal Time. Rules for Preparation of Networks and Steps in Network Preparation with example.

**BLOCK 4: PROGRAMME EVALUATION TOOLS**

**UNIT-1: Bennett's Hierarchy of Evaluation**

**Introduction to Bennett's hierarchy–** Background and description; **Relation between programme objectives & outcomes at 7 levels of Bennett's hierarchy –** Inputs, activities, participation, reactions, KASA changes, practice and behaviour changes, end results. Advantages and Disadvantages of Bennett's hierarchy.

**UNIT-2: Logic Framework Approach (LFA)**

**Introduction to LFA–** Background and description; **Variations of LFA** - Goal Oriented Project Planning (GOPP) or Objectives Oriented Project Planning (OOPP); **LFA Four-by- Four Grid –** Rows from bottom to top (Activities, Outputs, Purpose and Goal & Columns representing types of information about the events (Narrative description, Objectively Verifiable Indicators (OVIs) of these events taking place, Means of Verification (MoV) where information will be available on the OVIs, and Assumptions). Advantages and Disadvantages of LFA.

**BLOCK 5: IMPACT ASSESSMENT**

**UNIT-1: Introduction to Impact Assessment**

**Concept of Impact Assessment:** Meaning, concept and purpose in different contexts; **Impact Assessment Framework:** Meaning of inputs, outputs, outcomes, impacts and their relation with monitoring, evaluation and impact assessment.

**UNIT-2: Impact Assessment Indicators**

Indicators for impact assessment – meaning and concept; Selecting impact indicators; Types of impact indicators for technology and extension advisory services - social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.

**UNIT-3: Approaches for Impact Assessment**

**Impact assessment approaches–** Quantitative, qualitative, participatory and mixed methods with their advantages and disadvantages; **Quantitative Impact Assessment Types–** Based on Time of Assessment (Ex-ante and ex-post), Based on Research Design (Experimental, quasi experimental, Non-experimental). **Econometric Impact Assessment:-** (Partial Budgeting Technique, Net Present Value, Benefit Cost Ratio, Internal Rate of Return, Adoption Quotient *etc*). Qualitative and Participatory Impact Assessment Methods.

**UNIT-4: Environment Impact Assessment (EIA)**

**Concept of EIA–** Introduction, What it is? Who does it? Why it is conducted? How it is done?; **Benefits and important aspects of EIA-**risk assessment, environmental management and post product monitoring. **Environmental Components of EIA–** air, noise, water, biological, land; Composition of the expert committees and Steps in EIA process screening, scoping, collection of baseline data, impact prediction, mitigation measures and EIA report, public hearing, decision making, monitoring and implementation of environmental management plan, assessment of alternatives, delineation of mitigation measures and EIA report; **Salient Features of 2006 Amendment to EIA Notification-** Environmental Clearance/Rejection, participants of EIA; Shortcomings of EIA and How to improve EIA process?

**PRACTICAL**

1. Search the literature using web/ printed resources and identify evaluation indicators for the following:
   - Utilization-Focused Evaluation
   - Values Engaged Evaluation
   - Empowerment Evaluation
   - Theory-Driven Evaluation
2. Visit Directorate of Extension in your university and enquire about extension programmes being implemented/ coordinated by Directorate. Develop an evaluation proposal of any one programme using 'Ten Steps in Programme Evaluation' discussed in the theory class.
3. Review any comprehensive programme evaluation report from published sources. Evaluate the report and write your observations following the 'Evaluating the Evaluation' approach.
4. Identify at least four agriculture development programmes and their objectives being implemented in your state. Write two attributes each on Strengths, Weaknesses, Opportunities and Threats related to the identified programme objectives in the SWOT grid.
5. Identify an on-going development programme and make-out 6 activities from the programme. Draw a Gantt chart for 12 months programme activities.
6. Write a report on evaluation hierarchy levels and indicators as per Bennett's hierarchy of evaluation for any development programme or project.
7. Develop LFA four-by-four grid for any development programme or project with activities, outputs, purpose & goal and objectively verifiable indicators, means of verification & assumptions.
8. Visit a nearby KVKs/ ATIC. Select any agriculture technology with package of practices and extension advisory services promoted by KVK/ ATIC. Identify impact assessment indicators for social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.
9. Refer any Environment Impact Assessment report and analyze steps in EIA. Write your observations.

**TEACHING METHODS/ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)s
- Student's Book/Publication Review
- Student presentation
- Group Work
- Guest Lectures

**SUGGESTED READINGS**


1. Adrienne M, Gundel S, Apenteng E and Pound B. 2011. Review of Literature on Evaluation Methods Relevant to Extension. Lindau, Switzerland: Global Forum for Rural Advisory Services, Lindau, Switzerland.
2. Boyle R & Le Maire D. (1999). Building effective evaluation capacity: lessons from practice. New Brunswick, NJ: Transaction Publishers.
3. Bradford, R.W., Duncan, P.J. & Tarcy, B. 1999. Simplified Strategic Planning: A No- nonsense Guide for Busy People Who Want Results Fast. New York: Chandler House.
4. Braverman MT and Engle M. 2009. Theory and rigor in Extension program evaluation planning. Journal of Extension 47(3). www.joe.org/joe/2009june/a1.php
5. Chen, H.T. 2011. Practical program evaluation: Theory-Driven Evaluation and the Integrated Evaluation Perspective. Thousand Oaks, CA: Sage.
6. Murray P. 2000. Evaluating participatory extension programs: challenges and problems. *Australian Journal of Experimental Agriculture*, Vol. 40 No. 4 pp. 519–526.
7. Patton, M.Q. 2013. Utilization-Focused Evaluation (U-FE) Checklist. Western Michigan University Checklists.
8. Rosanne Lim. 2012. Why You Should Do a SWOT Analysis for Project Management.
9. Rossi PH and Freeman HE. 1985. Evaluation: a systematic approach (third edition). Beverly Hills, CA Sage Publications, Inc.
10. Srinath, L.S. 1975. PERT and CPM Principles and Applications, East-West Press, New Delhi.

11. Suvedi M, Heinze K and Ruonavaara D. 1999. How to Conduct Evaluation of Extension Programs. ANRECS Center for Evaluative Studies, Dept of ANR Education and Communication Systems, Michigan State University Extension, East Lansing, MI, USA.
12. Suvedi M. 2011. Evaluation of agricultural extension and advisory services- A MEAS training module. Urbana Champaign, IL: Modernizing Extension and Advisory Services Project.
13. Venkateswarlu, K and Raman, K.V. 1993. Project Management Techniques for R&D in Agriculture. Sterling Publishers Pvt.Ltd., New Delhi.


## EXT 531 ORGANISATIONAL BEHAVIOR AND DEVELOPMENT 3 (2+1)

**WHY THIS COURSE?**

In changing and competitive world, the survival of any organization is dependent on its ability to adjust to the new challenges, adapt its structure and develop the competencies needed among its staff. This course is designed to understand the theory and practice relating to the processes of organizational behavior, development and change. It attempts to bring about change in the different levels of the organization (the individual, group and organization) using a wide variety of interventions.

**AIM OF THIS COURSE**

1. To understand the theory and practice relating to the processes of organizational behavior, development and change.
2. To develop insight and competence in diagnostic and intervention processes and skills for initiating and facilitating change in organizations.
3. To gain necessary self-insight, skills in facilitation, organizational development (OD) skills, group process and techniques, to become an effective change agents and OD consultants.
4. To understand the behavior of individuals and small groups in organization with special focus on beliefs, attitudes and values, human inference - attribution, self- concept, motivation, active listening, interpersonal communication, conflicts management.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Organizational Behaviour | 1. Basics of Organization<br>2. Basics of Organizational Behaviour<br>3. Individual Behaviour in Organizations<br>4. Group Behaviour in Organizations<br>5. Productive Behaviour and Occupational Stress<br>6. Organizational Systems |
| 2. | Organizational Development | 1. Overview of Organizational Development<br>2. Managing the Organizational Development Process<br>3. Organizational Development Interventions<br>4. Organizational Development Practitioner or Consultant |

**COURSE OUTCOMES**

This course will equip the students to become potential change agents and OD practitioners. They should be able to learn how to improve individual, group/team and organizational performance through the use of OD techniques or interventions.

**THEORY**

**BLOCK 1: ORGANIZATIONAL BEHAVIOR**

**UNIT-1: Basics of Organization**

Introduction to organizations-concept and characteristics of organizations; Typology of organizations; Theories of organizations: nature of organizational theory, Classical theories, Modern management theories, System Theory- Criticisms and lessons learnt/analysis.

**UNIT-2: Basics of Organizational Behaviour**

Concepts of Organizational Behaviour, Scope, Importance, Models of OB

**UNIT-3: Individual Behaviour in Organizations**

Introduction, Self-awareness, Perception and Attribution, Learning, **Systems approach to studying organization needs and motives**– attitude, values and ethical behavior, Personality, **Motivation**-Concept & Theories, Managing motivation in organizations.

**UNIT-4: Group Behaviour in Organization**

Foundations of group, group behaviour and group dynamics, Group Development and Cohesiveness, Group Performance and Decision Making, Intergroup Relations; Teams in Organizations-Team building experiential exercises, Interpersonal Communication and Group; Leadership: Meaning, types, Theories and Perspectives on Effective Leadership, Power and Influence, managing Conflict and Negotiation skills, Job/ stress management, decision-making, problem-solving techniques.

**UNIT-5: Productive Behaviour and Occupational Stress**

**Productive behaviour**- Meaning, dimension; **Job analysis and Job performance**– meaning, dimensions, determinants and measurement; Job satisfaction and organizational commitment-meaning, dimensions and measures roles and role clarity; **Occupational stress-** meaning, sources, theories and models, effects, coping mechanism, effects and management; Occupational stress in farming, farmer groups/ organizations, research and extension organizations.

**UNIT-6: Organizational System**

**Organizations Structure**- Need and Types, Line & staff, functional, committee, project structure organizations, centralization &decentralization, Different stages of growth and designing the organizational structure; **Organizational Design**-Parameters of Organizational Design, Organization and Environment, Organizational Strategy, Organization and Technology, Power and Conflicts in Organizations, Organizational Decision-Making; Organizational Culture vs Climate.

**Organizational Change; Organizational Learning and Transformation**

**BLOCK 2: ORGANISATIONAL DEVELOPMENT**

**UNIT-1: Overview of Organizational Development**

Concept of OD, Importance and Characteristics, Objectives of OD, History and Evolution of OD, Implications of OD Values.

**UNIT-2: Managing the Organizational Development Process**

Basic **Component of OD Program**- Diagnosis-contracting and diagnosing the problem, Diagnostic models, open systems, individual level group level and organizational level diagnosis; **Action**-collection and analysis for diagnostic information, feeding back the diagnosed information and interventions; **Program Management**- entering OD relationship, contracting, diagnosis, feedback, planned change, intervention, evaluation.

**UNIT-3: Organizational Development Interventions**

Meaning, Importance, Characteristics of Organization development Interventions, **Classification of OD Interventions**-Interpersonal interventions, Team Interventions, Structural Interventions, Comprehensive Interventions.

**UNIT-4: Organizational Development Practitioner or Consultant**

Who is OD consultant? **Types of OD consultants and their advantages**, qualifications, Comparison of traditional consultants Vs. OD consultants, Organizational Development process by the practitioners skills and activities.

**PRACTICAL**

1. Case Analysis of organization in terms of process– attitudes and values, motivation, leadership;
2. Simulation exercises on problem-solving– study of organizational climate in different organizations;
3. Study of organizational structure of development departments, study of departmentalization; span of control, delegation of authority, decision-making patterns;
4. Study of individual and group behaviour at work in an organization;
5. Conflicts and their management in an organization;
6. Comparative study of functional and nonfunctional organizations and drawing factors for organizational effectiveness;
7. Exercise on OD interventions (Interpersonal, Team, Structural, Comprehensive) with its

procedure to conduct in an organization.

**TEACHING METHODS/ACTIVITIES**

- Lecture cum discussion
- Cases
- Class exercises
- Group Presentation

**SUGGESTED READINGS**


1. Bhattacharyya DK. 2011. Organizational Change and Development, Oxford University Press.
2. Hellriegel D, Sloccum JW and Woodman. 2001. Organizational Behaviour. Cincinnati, Ohio: South-Western College Pub.
3. Luthans F. 2002. Organizational Behaviour. Tata McGraw-Hill, New York.
4. Newstrom JW and Davis K. 2002. Organizational Behaviour: Human behaviour at Work. Tata-McGraw Hill, New Delhi.
5. Peter MS. 1998. The Fifth Discipline: The Art and Practice of Learning Organization. Random House, London.
6. Pradip NK. 1992. Organizational Designs for Excellence.Tata McGraw Hill, New Delhi.
7. Shukla, Madhukar. 1996. Understanding Organizations. Prentice Hall of India, New Delhi.
8. Stephens PR and Timothy AJ. 2006. Organizational Behaviour, 12th Edition. Prentice Hall Pub.
9. Thomas GC and Christopher GW. 2013. Organizational development and change, 10th edition, South-Western college publishing.
10. Wendell LF and Cecil HB. 1999. Organizational Development: Behavioural science interventions for organization improvement, Pearson. 368.


## EXT 532 MANAGING EXTENSION ORGANIZATIONS 3 (2+1)

**WHY THIS COURSE?**

Organizations need to follow management principles, objectives and organizational processes. The extension organizations including management of agricultural extension services need to be managed for effectiveness and efficiency. This calls for key business management skills to be learnt by the students so that they can run extension organizations, and extension and advisory services efficiently using the principles, practices, knowledge and skills required for effective management.

**AIM OF THIS COURSE**

- To orient students on the importance of knowledge and skills on various management functions, as applicable to extension organizations
- Discuss ways of running extension services as managers of agri-ventures
- To develop capacities for becoming effective managers of agri-ventures.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Basics of Management | 1. Management- An Overview |
| 2. | Management in different types of Extension organizations | 1. Extension Management in public, private sector and other sectors |
| | | 2. Concepts in Management |
| 3. | Motivation and Organizational Communication | 1. Motivation and Communication |
| | | 2. Supervision and Control |

**COURSE OUTCOMES:** After successful completion of this course, the students are expected to be able to:

1. Turn good managers of extension and advisory services including agri-ventures, FPOs, cooperatives *etc*.
2. understand the key business skills needed for managing agribusinesses and managing the value chains.
3. critically evaluate the Management functions to make extension systems efficient by applying management principles and good practices of effective management.

4. engage in management of extension organizations.

**THEORY**

**BLOCK 1: BASICS OF MANAGEMENT**

**UNIT-1: Management- An Over view**

**Management and Extension management** – Meaning, concept, nature and importance; and theories of management. **Management, administration and supervision**- meaning, definition and scope; Approaches to management, Principles, functions and levels of management; Qualities and skills of a manager; Interpersonal relations in the organization; Reporting and budgeting

**BLOCK 2: MANAGEMENT IN DIFFERENT TYPES OF EXTENSION ORGANIZATIONS**

**UNIT-1: Extension Management in public, private sector and other sectors**

**Extension management** (POSDCORB) in **public sector**, Department of Agriculture, Agricultural Technology Management Agency (ATMA), Krishi Vigyan Kendra (KVK), SAUs, ICAR Institutes, **Private sector, Cooperatives, NGOs, FPOs** *etc*. Organisational Structure, Relations between different units- Challenges in management

**UNIT-2: Concepts in Management**

**Decision making –** Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions; **Human Resource Management** Training and Development; Dealing with **fund and staff** shortages in different extension organizations (KVK, ATMA *etc*.); **Leadership**– Concept, Characteristics, Functions, Approaches to leadership, Leadership styles; **Authority and responsibility**, Delegation and decentralization, line and staff relations; **Challenges of co-ordination in extension organizations**; **Managing inter departmental coordination and convergence** between KVK, ATMA and line departments; **Coordinating pluralism in extension services**; Challenges in managing public-private partnerships (PPPs) at different levels in agricultural development in general and extension in particular; **Performance appraisal** – Meaning, Concept, Methods.

**BLOCK 3: MOTIVATION & ORGANIZATIONAL COMMUNICATION**

**UNIT-1: Motivation and Communication**

**Managing work motivation** – Concept, Motivation and Performance, Approaches to motivation, team building; **Organizational Communication** – Concept, Process, Types, Networks, Barriers to Communication; Mentoring, Time management, Team work and team- building strategies; Modernization of information handling

**UNIT-2: Supervision and Control**

**Supervision**– Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision; **Managerial Control**– Nature, Process, Types, Techniques of Control, Observation, PERT and CPM, **Management Information Systems** (MIS): Concept, tools and techniques, MIS in extension organizations.

**PRACTICAL**

1. Simulated exercises on techniques of decision making;
2. Study the structure and function of agro-enterprises, Designing organizational structure/ organograms;
3. Group activity on leadership development skills;
4. Simulated exercise to understand management processes;
5. Field visit to extension organizations (ATARI, KVKs, NGOs), FPOs, dairy cooperatives to understand the functions of management;
6. Practical exercises on PERT & CPM;
7. Group exercise on development of short term and long term plans for agro-enterprises;
8. Developing model agriculture-based projects including feasibility study, financial planning and cost-benefit analysis.

**TEACHING METHODS/ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)
- Student's Book/Publication Review
- Student presentation

– Group Work
– Student's interview of officers engaged in EAS
– Short attachments

**Suggested Readings:**


1. Bitzer V. 2016. Incentives for enhanced performance of agricultural extension systems, KIT Working Paper 2016-6, Royal Tropical Institute, Amsterdam.
2. Bitzer V, Wennik, B and de Steenhuijsen, B. 2016. The governance of agricultural extension systems, KIT Working Paper 2016-1Royal Tropical Institute, Amsterdam
3. Chand S. 2017. Modern Management Theory: Quantitative, System and Contingency Approaches to Management.
4. Gabathuler E, Bachmann F, Klay A. 2011. Reshaping Rural Extension Learning for Sustainability: An integrated and learning based advisory approach for rural extension with small scale farmers-Chapter 4. Margraf Publishesrs, Kanalstr.
5. GFRAS 2017. Module 3: Agricultural Extension Programme Management, The New Extensionist Learning Kit, Global Forum for Rural Advisory Services (GFRAS).
6. Gupta CB. 2001. Management Theory and Practice. Sultan Chand & Sons. New Delhi
7. HRM 2013. Current Trends in Human Resource Management https://corehr.wordpress.com/2013/08/21/current-trends-in-human-resource-management/
8. Koontz H and Weihrich H. 2015. Essentials of Management: An International, Innovation and Leadership perspective. McGraw Hill Education (India) Private Ltd.
9. MANAGE. 2008. Project Management in Agricultural Extension, AEM-203, Post Graduate Diploma in Agricultural Extension Management (PGDAEM), National Institute of Agricultural Extension Management, Hyderabad
10. Swanson BE, Bentz RP, Sofranko AJ. 1997. Improving Agricultural Extension. A Reference Manual. Food and Agriculture Organization of the United Nations, Rome.
11. Van den Ban AW and Hawkins HS. 1998. Agricultural extension- Chapter 10, BSL, CBS Publishers and Distributors.


## EXT 533 ENABLING INNOVATION 2(1+1)

**WHY THIS COURSE?**

An effective process of agricultural innovation is a pre-condition for meeting the global challenge of feeding the growing world population and reducing poverty. Ideas about innovation have evolved considerably over the past 4 decades. A frequently used term in the discussions around innovation in agriculture is 'Agricultural Innovation Systems' (AIS). The AIS is increasingly recognized as a useful framework to diagnose innovation capacity, design investment and organize scaling up interventions. Extension and Advisory Services (EAS) are integral to AIS. Extension professionals should have sound knowledge on how to scale up new knowledge and thereby enabling innovation and impact and their roles in strengthening AIS. This course aims to provide these perspectives.

**AIM OF THIS COURSE**

The aim of this course is to introduce the new perspectives related to "innovation" and help learners to apply the AIS framework especially in dealing with scaling up knowledge. It discusses the different ways to explore AIS including the roles of different actors and the enabling environment (including institutions and policies) in enabling innovation. The course also aims to broaden the understanding of students in scaling up knowledge and orient students to varied tools and approaches to scaling up.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1 | Agricultural Innovation Systems | 1.Agricultural Innovation Systems: Concepts and Elements |
| | | 2.Enabling Innovation |
| 2 | Scaling Up Knowledge for Innovation | 1. Scaling Up: Tools, Approaches and Pathways |

**COURSE OUTCOMES:**

After successful completion of this course, the students are expected to be able to:

1. Appreciate and apply AIS framework in different contexts;

2. Enhance their knowledge and skills related to enabling innovation;
3. Diagnose AIS and design interventions for improvement and
4. Design scaling up strategies to achieve innovation and impact.

**THEORY**

**BLOCK 1: AGRICULTURAL INNOVATION SYSTEMS**

**UNIT-1: Agricultural Innovation Systems: Concepts and Elements**

**Origins of the innovation systems concept**-Innovation vs Invention; **Agricultural Innovation System** (AIS) -ToT, FSR, AKIS and AIS compared, **Key insights from AIS**: How Innovation takes place; **Role of different actors in AIS**; Importance of interaction and knowledge flows among different actors, **Role of Communication in Innovation Process**; Role of Extension in AIS, **Different views to analyze AIS**: structural view, functional view, process view and capacity view;

**UNIT-2: Enabling Innovation**

**Role of enabling environment**: Policies and institutions in enabling innovation; Role of Government-**Innovation Policy**: Achieving coordination and policy coherence; Innovation Platforms; Role of Innovation Brokers, **Methodologies for AIS Diagnosis:** Typologies of existing methodologies-strengths and limitations; Assessing Extension and Advisory Services within AIS; **Capacity Development in AIS:** Strengthening capacities to innovate,

**BLOCK 2: SCALING UP KNOWLEDGE FOR INNOVATION**

**UNIT-1: Scaling Up: Tools, Approaches and Pathways**

**Scaling Up**: Definitions; Changing views on scaling up: **Approaches to Scaling Up**: Push, pull, plant, probe: **Scaling up pathways**: Drivers and spaces for scaling up; Framework and Tools for Scaling up: **Planning and implementing a scaling up pathways**; Scalability assessment tools; **Role of policies in scaling up**: Influencing policies for scaling up; **Innovation Management** for scaling up knowledge and implications for Extension and Advisory Services

**PRACTICAL**

1. Identify one crop/commodity sector and use AIS framework to diagnose actors and their roles, patterns of interaction, institutions determining interaction and the enabling policy environment and develop a AIS Diagnosis Report (Review and Key informant interviews);
2. Undertake a case study on a successful case of scaling up knowledge and identify factors that contributed to its success;
3. Identify one specific knowledge (a technology, an approach) that has been recently introduced and develop an Up scaling Strategy.

**TEACHING METHODS/ACTIVITIES**

– Lecture
– Assignment (Reading/Writing)s
– Student's Book/Publication Review
– Student presentation
– Group Work

**SUGGESTED READINGS**

1. Binswanger HP and Aiyar SS. 2003. Scaling Up Community Driven Development Theoretical Underpinnings and Program Design Implications. Mimeo. Washington, D.C.: World Bank..
2. Chuluunbaatar D and LeGrand S. 2015. Enabling the Capacity to Innovate with a system-wide assessment process. Occasional papers on Innovation in Family Farming. Food and Agriculture Organization of the United Nations. http://www.fao.org/3/a-i5097e.pdf
3. Davis K and Heemskerk W. 2012. Coordination and Collective Action for Agricultural Innovation Overview Module 1 Investment in Extension and Advisory Services as Part of Agricultural Innovation Systems. In Agricultural Innovation Systems: An Investment Sourcebook. Agricultural and Rural Development. World Bank. © World Bank.
4. Davis K and Sulaiman RV. 2016. Extension Methods and Tools. Module 2 NELK. GFRAS.
5. Heather C. 2008. Scale-up and replication for social and environmental enterprises. International Institute for Sustainable Development.
6. IFAD 2011. Section XXI: Guidelines for Scaling Up. Updated Guidelines and Source Book for Preparation and Implementation of a Results-Based Country Strategic Opportunities Programme (RB-COSOP). Vol. 1:Guidelines, International Fund for Agricultural Development.

7. ILRI. 2014. Innovation Platform practice briefs. International Livestock Research Institute.
8. OECD. 2012. Innovation for Development. A Discussion of the Issues and an Overview of Work of the OECD Directorate for Science, Technology and Industry.
9. OECD. 2013. Agricultural Innovation Systems: A Framework for Analysing the Role of the Government, OECD Publishing, Paris, https://doi.org/10.1787/9789264200593-en.
10. Patton and Quinn M. 2008. Evaluating the complex: Getting to maybe. Oslo, Norway.
11. Posthumus H and Wongtschowski M. 2014. Innovation Platforms. Note 1. GFRAS good practice note for extension and advisory services. GFRAS: Lindau, Switzerland. Available at:
12. Rajalahti R, Janssen W and Pehu E. 2008. Agricultural innovation systems: From diagnostics toward operational practices. Agriculture & Rural Development Department, World Bank.
13. Saravanan R and Suchiradipta B. 2017. Agricultural Innovation Systems: Fostering Convergence for Extension. Bulletin 2, Extension Next. MANAGE.

## EXT 534 GENDER MAINSTREAMING 3(2+1)

**WHY THIS COURSE?**

Gender as a concept has gained well deserved attention globally. Development planners and policy makers have realized that gender implications need to be considered while planning and implementing programmes and projects for their desired impacts. Conversely, the impacts of programmes on men and women also vary due to their different socially ascribed roles and responsibilities. Extension professionals need to understand the concept of gender and its implications on agricultural and rural development and their skills need to be built for critically identifying and analyzing gender implications. This course is designed to meet these requirements.

**AIM OF THIS COURSE**

1. To orient students on the importance of “Gender mainstreaming” as well as the other concepts related to gender. The students will be able to understand the gender roles and responsibilities and how in the present times, the roles may be shifting.
2. To discuss ways and various techniques for conducting gender analysis theoretically and practically as well as the prerequisites for gender analysis.
3. To develop capacities for identifying and addressing gender implications in all development programmes related to agriculture and allied sectors, climate change adaptation and livelihood security, as well as addressing gender issues through application of extension methods including PRA and PLA.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Why Gender Matters | 1.Historical Perspective of Gender |
| | | 2.Agrarian Importance of Gender |
| 2. | Gender Related Concepts, Analysis, Gender and Technology | 1.Gender Related Concepts and Divides |
| | | 2.Gender Analysis |
| | | 3.Gender and Technology |
| 3. | Gender Mainstreaming and Women Empowerment | 1.Gender Mainstreaming |
| | | 2.Women Empowerment |
| | | 3.Global Best Practices, Policies and Frameworks |
| | | 4.Entrepreneurship Development for Women |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Appreciate the importance of addressing agrarian gender concerns in the context of sustainable livelihoods and national development.
2. Understand the various concepts related to gender and the application of these concepts for women empowerment and gender mainstreaming.
3. Critically evaluate the various agricultural development, rural development programmes, schemes, policies and strategies for women empowerment within the context of achieving gender equity.
4. How to engage in gender analysis and collect and analyze sex-disaggregated data for developing strategies for women empowerment and gender mainstreaming.

**THEORY**

**BLOCK 1: WHY GENDER MATTERS?**

**UNIT-1: Historical Perspective of Gender**

**Historical perspective of gender:** Feminism and emergence of gender as a concept, Scope of gender studies in agriculture and rural development.

**UNIT-2: Agrarian Importance of Gender**

**Agrarian Importance of Gender:** Understanding the importance of gender in national and global agriculture-Key gender issues and challenges in agriculture - Gender and value chain- Global actions to address gender-needs and strategies to address gender and women empowerment.

**BLOCK 2: GENDER RELATED CONCEPTS, ANALYSIS, GENDER AND TECHNOLOGY**

**UNIT-1: Gender Related Concepts and Divides**

**Gender related concepts and divides:** Understanding of the concepts of gender, gender equality and equity, gender balance, gender blindness, gender relations, gender neutrality, gender bias and discrimination, gender rights, gender roles and responsibilities. Gender budgeting, Gender divides and their implications such as gender digital divide, gender access to resources and inputs divide, gender mobility divide, gender wage divide, **Gender needs:** practical and strategic.

**UNIT-2: Gender Analysis**

**Gender analysis:** Importance, usage, prerequisites, techniques of gender analysis-Tools for gender analysis

**UNIT-3: Gender and Technology**

**Gender and technology:** How gender and technology impact each other, Gender neutral technology, Gender sensitive technology, Gender supportive assistance in technology adoption-Gender in agricultural research and extension.

**BLOCK 3: GENDER MAINSTREAMING AND WOMEN EMPOWERMENT**

**UNIT-1: Gender Mainstreaming**

**Gender mainstreaming:** Importance of gender mainstreaming in agriculture, Extension strategies to address gender issues such as gender and health, nutrition, gender in agricultural value chains, gender and climate change adaptation, gender and globalization& liberalization for mainstreaming gender concerns into the national programmes and policies.

**UNIT-2: Women Empowerment**

**Women Empowerment:** Importance of women empowerment, Current national women empowerment and gender indices. Women empowerment approaches (technological, organizational, political, financial, social, legal and psychological), Case studies based on experiences and learning from various development and rural development programmes.

**UNIT-3: Global Best Practices, Policies and Frameworks**

**Global Best Practices, Policies and Frameworks:** Global best practices, women empowerment and gender mainstreaming models and frameworks for addressing gender concerns in agriculture, approaches of various organizations: gender mainstreaming and special women focused programmes in agriculture and rural development.

**UNIT-4: Entrepreneurship Development for Women**

**Entrepreneurship development for women:** Women entrepreneurship development in agriculture and agro processing: current status, **women led enterprises,** supporting **organizations and schemes, Govt. policies,** entrepreneurship development programme and process for women in agriculture.

**PRACTICAL**

1. Visit to a village for understanding rural gender roles and responsibilities as groups, followed by class presentation by groups;
2. Exercise for capturing shifts in gender roles and responsibilities;
3. Conducting gender analysis in a village using gender analysis techniques;
4. Visit to agencies supporting women empowerment followed by report presentation. Each student to visit a different organization such as State Rural Livelihood Mission, Women Development Corporation, Department of Agriculture, Important NGOs working for women

empowerment;
5. Exercise for identification and prioritization of issues affecting/needs for women empowerment;
6. Interaction with a successful women entrepreneur/ SHG.

**TEACHING METHODS/ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)s
- Student's Book/Publication Review
- Student presentation
- Group Work
- Student's interview of key policy makers
- Case Analysis
- Guest Lectures
- Review of policy documents
- Short attachments

**SUGGESTED READINGS**


1. AGRIPROFOCUS 2014. Gender in value chains Practical toolkit to integrate a gender perspective in agricultural value chain development.
2. Cristina M, Deborah R, Andrea A, Gale S, Kathleen C, Mercy A.2013. Reducing the Gender Gap in Agricultural Extension and Advisory Services: How to find the best fit for men and women farmers MEAS Discussion Paper 2, Modernizing Extension and Advisory Services.
3. GFRAS. 2013.Gender equality in Rural Advisory Services, Towards a Common Understanding. Global Forum for Rural Advisory Services, Switzerland.
4. GFRAS. 2013. Gender equality in Rural Advisory Services. Global Forum for Rural Advisory Services,Switzerland.
5. GFRAS. Gender in Extension and Advisory Services, Module 12, GFRAS New Extensionist Learning Kit (NELK).Global Forum for Rural Advisory Services.
6. Grover I and Grover D. 2002.Empowerment of Women. Agrotech Publishing Academy.
7. JAEE (Editorial article). 2013. Gender Inequality and Agricultural Extension. *The Journal of Agricultural Education and Extension* Vol **19(5)** 433-436.
8. Jaiswal S. 2013. Research Methodology in Gender Studies. Maxford Dynamic Series:1- 296.
9. Pena I, Garrett J. 2018.Nutrition-sensitive value chains-A guide for project design. International Fund for Agricultural Development (IFAD).
10. Raj MK. 1998. Gender Population and Development. Oxford Univ. Press
11. Rhoda MM and Kabisa M.2016. Analysis of Indicators and Management Tools Used in Zambia to assess impact of Agricultural Extension Programmes on Gender Equity and Nutrition Outcomes.
12. Sahoo RK and Tripathy SN. 2006. SHG and Women Empowerment. Anmol Publ.
13. Sinha K. 2000. Empowerment of Women in South Asia. Association of Management Development Institute in South Asia, Hyderabad.

# COURSE CONTENTS: Ph.D. EXTENSION EDUCATION

## EXT 611 POLICY ENGAGEMENT AND EXTENSION 3 (2+1)

**WHY THIS COURSE?**

Extension's performance in any country to a large extent is dependent on the wider policy and institutional context prevailing at the national level. At the organizational level, extension should have capacities to influence policies that affect their performance. To effectively influence policies, extension professionals need to generate not only sound evidence of its impact, but also capacities to engage with policy relevant actors especially at various levels. While few countries have developed specific extension policies, there has been very limited success in translating these policies into programmes and operational guidelines. Lack of policy relevant research to generate evidence on extension's impact; poor documentation of successful initiatives, and lack of training on engaging with policy relevant actors have all contributed to this. Extension professionals, often encounter situations where existing policy constraints development interventions or where new policies could better support development. This course is aimed at developing these capacities to successfully engage with policy actors and bringing about desirable policy changes to strengthen extension.

**AIM OF THIS COURSE**

- To orient students on the importance of policies in shaping extension's performance;
- To discuss ways of generating policy relevant evidence to influence policies;
- To develop capacities to engage with policy actors and the policy development process.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Why policies matter? | 1. Understanding Policy |
| | | 2. Policy Advocacy and Tools |
| | | 3. Policy Analysis |
| | | 4. Policy Development Process |
| 2. | Using evidence to influence Policy Change | 1. Influencing Policy Change |
| | | 2. Global Experience with Extension Policy |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Appreciate the role of policies in shaping performance of extension;
2. Understand how to generate and communicate policy relevant evidence;
3. Critically evaluate extension policies in different countries;
4. How to engage in policy advocacy.

**THEORY**

**BLOCK 1: WHY POLICIES MATTER?**

**UNIT-1: Understanding Policy**

**Why policies are important for extension?** Role in providing structure, ensure funding and framework for providing functions-examples; **Policy:** definitions and types: Is policy a product or a process or both? Policies and institutions-How these influence defining organisational roles and performance in extension organizations. **Role of policies in upscaling knowledge**-Role of extension in influencing policies to enable innovation.

**UNIT-2: Policy Advocacy and Tools**

**Definition of advocacy**, **Approaches to policy advocacy**- Advising, Media campaigning, Lobbying, Activism, Information Education Communication (IEC) and Behavior Change Communication (BCC); Advocacy for Rural Advisory Services (RAS); Policy advocacy strategy.

**UNIT-3: Policy Analysis**

Explain the meaning and use of policy analysis in decision- making; Describe different types of policy analysis- empirical, evaluative or normative policy analysis, retrospective/ prospective policy analysis, predictive/prescriptive/descriptive policy analysis; How to do policy analysis? - understand the process of policy analysis, highlight the different methods and techniques used in policy analysis, doing ethical policy analysis; **Tools for policy impact-** research tools, context assessment tools, communication tools, policy influence tools.

**UNIT-4: Policy Development Process**

**Policy development process:** Who drives policy change?: National Governments, Donors, Civil Society-varied experiences: **Understanding the environment and key actors in policy space**-problem identification-policy adoption, implementation and evaluation; stakeholder mapping, identifying opportunities and barriers, mobilising financial resources; **Dealing with policy incoherence:** identifying contradictions and challenges in policy implementation.

**BLOCK 2: USING EVIDENCE TO INFLUENCE POLICY CHANGE**

**UNIT-1: Influencing Policy Change**

**Generating evidence:** Role of policy research; analysing the usefulness and appropriateness of the evidence; Using evidence in policy advocacy; **Understanding your audience:** analysing channels of influence**;** creating alliances; identifying policy champions**; Defining goals and objectives; Developing advocacy messages:** Policy papers, Policy briefs, good practice notes *etc.***:** **Good practices in influencing policies** Organising policy dialogues: Policy engagement strategy-Engaging with policy makers: GO and NGO experiences; Policy working groups; advisory panels; use of committees: **Use of media including ICTs and social media for influencing policies.**

**UNIT-2: Global Experience with Extension Policy**

**Extension policy in different countries: Explicit extension policy Vs extension as part of Agriculture Policy, Challenges in policy implementation:** lack of capacities, financial resources, ownership, lack of stakeholder consultations: Strengthening capacities in extension to influence policies: Global Forum for Rural Advisory Services **(GFRAS)'s efforts in strengthening extension policy advocacy:** policy compendium, training modules, training for strengthening capacities to influence policies.

**PRACTICAL**

1. Analysis of country/state level agricultural/extension policy to understand the policy intentions from strengthening EAS;
2. Analysis of extension policy of other countries: policy intentions, processes adopted in development of the policy and mechanisms of policy implementation;
3. Interview key policy actors in EAS arena at the state/national level (eg: Director of Agriculture, Director of Extension in SAU, Chairman/Managing Director of Commodity Board. Member Agriculture, State Planning Board) to explore policy level challenges in EAS;
4. Identify what evidence policy makers look for from extension research? Is the evidence available? If so what form? (Reports, Briefs *etc*), If not, develop a plan;
5. Explore how different stakeholders influence policies (eg: policy advocacy of prominent NGOs, private sector and public sector) -What mechanisms and tools they use;
6. Identify policy level bottlenecks that constrain effective EAS delivery at the district level- Eg: Issues around linkages between KVK and ATMA; inter-departmental collaboration; public private partnerships; joint action *etc*.

**TEACHING METHODS/ACTIVITIES**

1. Lecture
2. Assignment (Reading/Writing)s
3. Student's Book/Publication Review
4. Student presentation
5. Group Work
6. Student's interview of key policy makers
7. Case Analysis
8. Guest Lectures
9. Review of policy documents
10. Short attachments

**SUGGESTED READINGS**

1. CRISP, MANAGE and ICAR-ATARI.2016. Training cum workshop on Strengthening Extension Policy Interface at MANAGE on 9-11th Nov, 2016 in collaboration with the CRISP & ICAR-ATARI, Bangalore. http://crispindia.org/index.php/events/

2. DAC. 2000. Policy frame work for agricultural extension. Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India.
3. Dube L, Nii A Addy, Blouin C and Drager N. 2014. From policy coherence to 21st century convergence: A whole-of-society paradigm of human and economic development. Annals of the New York Academy of Sciences. 1331: 201–215.
4. GFRAS. 2018. RAS Policy Compendium. Global Forum for Rural Advisory Services, Switzerland.
5. GoI. 2011.Report of the Working Group on Agricultural Extension for Agriculture and Allied Sectors for the Twelfth Five Year Plan (2012-17), Section V-Recommendations IV,73-74.
6. Klaus von Grebmer. 2014. Converting Policy Research into Policy Decisions: The Role of Communication and the Media. IFPRI.
7. Nicholas J Sitko, Babu S, and Hoffman B. 2017.Practitioner's Guidebook and Toolkit for Agricultural Policy Reform: The P.M.C.A. Approach to Strategic Policy Engagement. Research Paper 49. Feed the Future Innovation Lab for Food Security Policy.
8. Sharma R.2002.Reforms in Agricultural Extension: New Policy Framework. Economic and Political Weekly. Vol.**37**, No.30 pp.3124-3131.
9. Sprechmann .S and Pelton .E 2001.Advocacy Tools and Guidelines Promoting Policy Change. Cooperative for Assistance and Relief Everywhere, USA.
10. Start D and IngieHovland. 2004. Tools for Policy Impact: A Handbook for Researchers. Overseas Development Institute.


## EXT 612 METHODOLOGIES FOR SOCIAL AND BEHAVIOURAL RESEARCH 3 (2+1)

**WHY THIS COURSE?**

In general, social and behavioural science research plays a crucial role in the professional development in a subject domain, through advancing knowledge and developing working modalities and standards. Precisely, the empirical research helps to develop robust and outcome focused working strategies, processes and models to enable the professionals to maximize their efficiency. This course on advanced social science research caters to the need to equipping the scholars with essential skills in conducting high quality research which helps them to design working strategies, processes and models for professional development.

**AIM OF THIS COURSE**

This course aims to equip the doctoral students to conduct outcome-oriented social and behavioural science research and to develop sound field focused extension strategies and models with adequate replicability, while advancing knowledge on processes governing success of those strategies. The focus of the course is on equipping the scholars with advanced capacities in conducting systematic, objective and outcome oriented research by applying state-of-art methods and tools at every stage of research from planning to publishing.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Advanced methods of improving quality research data | 1.Measurement Properties of Research Instruments |
| | | 2.Threats to Data Quality |
| 2. | Scales, indexes and tests | 1.Scales , Indexes and Tests – 1 |
| | | 2.Scales, Indexes and Tests - 2 |
| 3. | Emerging research approaches and designs | 1.Qualitative Research Methods |
| | | 2.Emerging Approaches |
| 4. | Utilizing research outputs | 1.Publishing Research |
| | | 2.Ethics in Extension Research |

**COURSE OUTCOMES**

1. The scholars should develop critical skills in conducting systematic and objective research by using robust methods while minimizing biases and errors
2. The students should intelligently choose and apply advanced methods and tools at every stage of research and execute them in a objective way by managing the actors and processes effectively.

3. The students should develop expertise in designing tests, scales and indexes along with other tools to measure the socio-psychological processes at individual, group and community levels.

**THEORY**

**BLOCK 1: ADVANCED METHODS FOR IMPROVING QUALITY OF RESEARCH DATA**

**UNIT-1: Measurement Properties of Research Instruments**

**Measurement properties**– Dimensionality, reliability and validity; **Dimensionality**– Uni-dimensionality and multidimensionality, Methods of assessing dimensionality, Formative and reflective constructs; **Validity**- Importance, Internal validity- face validity; content validity, Substantive Validity, Structural Validity; **External validity**- Convergent and Discriminant Validity, known-group validity, Criterion-Related Validity, Consequential Validity, nomological validity; Methods of assessing various forms of validities– Judges rating, Lawshe's Content Validity Ratio, Item-objective congruence index; latent variable method; **Reliability**- Internal consistency reliability– Split-Half, Cronbach alpha; Temporal Stability reliability- test-retest method; Interrater Consistency and Consensus – inter rater reliability and interrater agreement; **Alternative Forms or parallel forms reliability**– Reliability of difference- Factors Affecting the Validity and Reliability of Test Scores; Generalizability Theory.

**UNIT-2: Threats to Data Quality**

Errors and biases; **Errors–** Meaning and sources; Types- Sampling error, **Non-sampling or measurement error and Processing error**– Meaning, causes; Effects of errors and biases on data quality; **Bias in behavioural research**– Meaning, causes, Types– Respondent and researcher biases; Methods of reducing errors and biases in surveys, questionnaires, personal interviews, focus groups and online methods

**BLOCK 2: SCALES, INDEXES AND TESTS**

**UNIT-1: Scales, Indexes and Tests – 1**

**Approaches to measurement and scale development** - Classical test theory. Formative or index models, The C–OAR–SE approach and Item Response Theory; Item analysis in Classical test theory– item difficulty and item discrimination; Scoring performance in scales and tests– meaning, types and methods; **Scale development strategies–** deductive and empirical; Stimulus-centred scales – method of equally appearing intervals, paired comparison, Person scaling– Q methodology; Subject-centre scales– The Likert scale and Semantic Differential.

**UNIT-2: Scales, Indexes and Tests – 2**

Steps in constructing a multi-dimensional scale using confirmatory factor analysis,; Response scales- Guttman's scalogram analysis and The Rasch method; **Indexes**– Meaning, types, importance; Similarities and differences with scales, Methods of constructing indexes; Common indexes used in extension. **Measurement invariance**– Meaning, types, methods of assessing measurement invariance. **Tests–** meaning, types, importance; steps in conducting various tests – knowledge test.

**BLOCK 3: EMERGING RESEARCH APPROACHES AND DESIGNS**

**UNIT-1: Qualitative Research Methods**

**Qualitative methods**– Meaning; Types– Ethnography, Grounded theory, Phenomenology, Ecological psychology, Discourse Analysis; Observational research; Case study research– Sampling and sample size; **Data collection methods** - In-depth interviews, Focus groups, Direct observation, Record review; Content analysis; Unobtrusive Measures; Projective and semi-projective techniques; **Selecting right qualitative method–** Strengths and limitations of qualitative research; Analysis and interpretation of qualitative research data; **Research synthesis**– meaning, importance, methods; **Systematic reviews and meta analysis–** meaning, steps, and applications; Policy research.

**UNIT-2: Emerging Approaches**

**Mixed methods research–** meaning, purpose, types and applications; **Participatory research–** Meaning, importance, types, methods and tools and applications; **Action research**– Meaning, importance, Principles, Types, Steps in conducting action research, application in behavioural sciences. **Social Network Analysis**– Meaning, importance, types, steps in social network analysis, applications; advanced methods of measuring perception and beliefs. Multi criteria decision making, analytical hierarchy approach.

**BLOCK 4: UTILISING RESEARCH OUTPUTS**

**UNIT-1: Publishing Research**

Scholarly communication process; **Research reports**– Meaning, types, contents; **Presentations**– Meaning, types, principles of good presentation - Tell 'Em" and KISS 'Em" principles; **Research publications–** meaning, importance, types; **Guidelines for preparing research papers** - Peer review process, citation styles; Open access publishing; Publishing in social media. Software in academic writing.

**UNIT-2: Ethics in Extension Research**

Ethics in conducting behavioural research; **Human subject research–** Meaning, history, and ethical guidelines; Ethical aspects of collecting and using Indigenous knowledge and farmers technologies; Ethical practices in publishing ; **Plagiarism–** meaning, sources, Identifying and correcting plagiarism in a research paper using anti-plagiarism software.

**PRACTICAL**

1. Practice in developing research instruments Methods reliability of assessing measurement properties of research instruments dimensionality, and validity;
2. Hands-on exercise in minimizing errors and biases;
3. Hands-on experience in constructing tests, scale and indexes;
4. Practice in summated scale development using confirmatory factor analysis;
5. Hands on experience in assessing measurement invariance;
6. Practicing and collecting data using participatory tools and techniques, analyzing and interpreting qualitative data;
7. Hands-on experience in writing systematic review using meta-analysis;
8. Field practice in conducting action research;
9. Practical experience in writing research paper;
10. Hands on exercises using software for qualitative data analysis;
11. Practice in detecting and correcting plagiarism using software.

**TEACHING METHODS/ACTIVITIES**

1. Lecture
2. Assignment(Reading/Writing)s
3. Student presentation
4. Group Work
5. Guest Lectures
6. Research Report (Writing)

**SUGGESTED READINGS**


1. Berg B. 2009. Qualitative Research. Methods for the Social Sciences. Boston: Allyn & Bacon.
2. Creswell JW. 2007. Qualitative inquiry and research design: Choosing among five approaches ($2^{nd}$ ed.). Thousand Oaks, CA: SAGE Pub.
3. Edwards AL. 1957. Techniques of attitude scale construction. East Norwalk, CT, US: Appleton-Century-Crofts.
4. Furr, RM. 2011.Scale construction and psychometrics for social and personality psychology. Los Angeles: SAGE Pub.
5. Malhotra, NK. 2010. Marketing research: An applied orientation. Sixth Edition. Upper Saddle River, NJ: Prentice Hall Pub.
6. Netemeyer RG, Bearden WO and Sharma S. 2003.Scaling procedures: issues and applications. Thousand Oaks: SAGE Publications.
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8. Rao, CR and Sinharay S. 2007. Handbook of Statistics, Vol. **26**: Psychometrics, The Netherlands; Elsevier Science B.V.
9. Raykov T and Marcoulides GA. 2010. Introduction to Psychometric Theory. New York, NY: Taylor & Francis.
10. Scott J and Carrington PJ. 2011. The SAGE handbook of social network analysis. London: SAGE.

11. Sekaran U and Bougie R. 2013. Research Methods for Business A Skill-Building Approach. 6th Edition, Wiley, New York.
12. Sivakumar PS, Sontakki BS, Sulaiman RV, Saravanan R and Mittal N. (eds). 2017. Good Practices in Agricultural extension Research. Manual on Good Practices in Extension Research and Evaluation. Agricultural Extension in South Asia. Centre for research on innovation and science and policy (CRISP), Hyderabad. India.

## EXT 613 TECHNOLOGY COMMERCIALISATION AND INCUBATION 3 (2+1)

**WHY THIS COURSE?**

The technology commercialization and incubation is an emerging area which links technology development, transfer and commercialization processes with entrepreneurship development. Technology commercialization aims to realize the value of agricultural technologies developed at the research establishments, by maximizing their utility to stakeholders. With the increasing awareness of protecting and commercializing the Intellectual Property Resources (IPR) in the free market economy, there is a need to understand the organic relationship between protection and commercialization IPR, and entrepreneurship development.

**AIM OF THIS COURSE**

This course is aimed to develop a critical understanding among extension students about how the technology commercialization process is linked to IPR management and entrepreneurship development.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Technology commercialization and the modern context | 1. Basics of Technology Commercialization<br>2. Nature of Agricultural Technology<br>3. Basics of Technology Transfer and commercialization |
| 2. | Intellectual Property Resources (IPR) Management | 1. Overview of Intellectual Property Resources<br>2. Systems for protecting IP Management of IPR<br>3. Protection and Management of Biological Resources<br>4. Protection, Management and commercialization of Grass root and Farmers Innovations, Traditional and Indigenous Knowledge<br>5. Geographical Indications (GI) and appellation of Origin Genetically Modified Organisms (GMO),<br>6. Agriculture and Biosafety |
| 3. | Technology commercialization | 1. Technology Assessment and Refinement<br>2. Technology Valuation<br>3. Technology commercialization Strategies<br>4. Scaling up of Technologies<br>5. Technology Licensing<br>6. Technology Takers and Entrepreneurship<br>7. Policy Support for Technology commercialization and Entrepreneurship Development |
| 4. | Technology Incubation | 1. Basics of Technology Incubation<br>2. Technology Incubation in India |
| 5. | Technology Promotion and essential skill for technology commercialization | 1. Technology promotion<br>2. Dealing with Entrepreneur, Agripreneur and other stakeholders |
| 6. | Emerging approaches in technology commercialization and incubation | 1. Technology scouting |

**COURSE OUTCOMES:** At the end of the course the students are expected to develop competencies in

1. Enabling stakeholders to protect and manage their IPR;

2. Managing IPR to maximize their value realization through commercialization, and
3. Providing mentoring and handholding support to agripreneurs, rural entrepreneurs, start-ups, Farmer Organizations and other forms of entrepreneurs through incubation.

**THEORY**

**BLOCK 1: TECHNOLOGY COMMERCIALISATION AND THE MODERN CONTEXT**

**UNIT-1: Basics of technology commercialisation**

**Technology**- Definition, functions, process of technological advancement– invention, discovery, innovation and technology**; types of innovation**- Basic research, Breakthrough innovation, **Disruptive Innovation and Sustaining Innovation**; Technology transfer and commercialisation.

**UNIT-2: Nature of Agricultural Technology**

**Agricultural technology** – meaning, types; technology generation system; technology life cycle

**UNIT-3: Basics of Technology transfer and commercialization**

**Technology transfer *Vs.* Commercialisation**; **Technology commercialisation process** – elements, models, systems and processes; **Technology transfer model**– research, disclosure, development and commercialisation.

**BLOCK 2: INTELLECTUAL PROPERTY RESOURCES (IPR) MANAGEMENT**

**UNIT-1: Overview of Intellectual Property Resources**

**Introduction to IPR**; Overview & Importance; Genesis; IPR in India and IPR abroad; Patents, copyrights, trademarks & trade secrets, geographical indication, industrial design; Emergence of IPR **Regimes and Governance Frameworks**- Trade-Related Aspects of Intellectual Property Rights (TRIPS), Convention on Biological Diversity (CBD), Cartagena Protocol, International Union for Protection of New Plant Varieties (UPOV), and BIMSTEC.

**UNIT-2: Systems for Protecting IP**

**IPR protection laws and systems**– National IPR Policy; and IPR laws; procedures for filing IP protection; Systems of IP protection and management in agricultural universities and research institutions and also by stakeholders.

**UNIT-3: Management of IPR**

**Mechanisms of IPR Management–** Institutional arrangement, IP Management processes– invention disclosure; IP portfolio management; Infringement management.

**UNIT-4: Protection and Management of Biological Resources**

Introduction; National Biodiversity Act (2002); Protection of Plant Varieties and Farmers Rights Act (2001); Guidelines for registration and transfer of biological resources; Farmers rights; Mechanisms of documenting/ collecting, protecting and commercializing farmers varieties and other biological resources; National Biodiversity Authority, PPVFRA and other agencies involved in management of biological resources in India. Access to Genetic Resources and Sharing of Benefits.

**UNIT-5: Protection, Management and commercialization of Grass root and Farmers Innovations, Traditional and Indigenous Knowledge**

**Traditional and Indigenous Knowledge, Grass root and Farmers Innovations**– Meaning, forms and importance; Systems of documentation, registration, protection and commercialisation. **Documentation of traditional indigenous knowledge**- Traditional Knowledge Digital Library (TKDL), Community Biodiversity Registers (CBRs), People's Biodiversity Registers (PBRs), Plant Biodiversity Register, and Honeybee Network.

**UNIT-6: Geographical Indications (GI) and Appellation of Origin**

**Geographical indications and appellation of origin**– meaning, origin; Geographical Indications of Goods (Registration and Protection) Act (1999); Documentation, registration and commercialisation of GI protected materials and processes.

**UNIT-7: Genetically Modified Organisms (GMO), Agriculture and Biosafety**

The Global Concerns on Use of Genetically Modified Organisms in Food and Agriculture; The Cartagena Protocol on Bio-safety; Regulation of GMO in India - Recombinant DNA Advisory Committee (RDAC), Institutional Bio-safety Committee (IBSC), Review Committee on Genetic Manipulation (RCGM), Genetic Engineering Approval Committee (GEAC), State Bio-safety Coordination Committee (SBCC) and District Level Committee (DLC). Laws and Acts for regulation of GMO- Guidelines for Research in Transgenic Plants, 1998; Seed Policy, 2002; Plant Quarantine Order, 2003; Regulation for Import of GM Products Under Foreign Trade Policy, 2006; National Environment Policy, 2006.

**BLOCK 3: TECHNOLOGY COMMERCIALISATION**

**UNIT-1: Technology Assessment and Refinement**

Meaning; Importance; Approaches and methods of assessment and refinement of various technologies – stakeholder oriented approaches including participatory technology assessment and refinement; assessment and refinement of traditional and indigenous knowledge and grass root innovations.

**UNIT-2: Technology Valuation**

**Returns to investment; IP Valuation**-Oxford context, **IP Valuation methods**- Cost approach; Income approach- Discounted Cash Flow, Risk-Adjusted Net Present Value, Net Present Value with Monte Carlo Simulation and Real Options Theory; **Market approach**- Industry Standards Method, Rating/Ranking Method, Rules of Thumb Approach and Auction Method; Hybrid approaches; Royalty rate method.

**UNIT-3: Technology commercialization Strategies**

Meaning- approaches for technology commercialization– technology scaling up, technology licensing, handholding, agripreneur development, technology business incubation.

**UNIT-4: Scaling up of Technologies**

Meaning, types and stages of technology scaling up; mechanisms.

**UNIT-5: Technology Licensing**

Meaning and types - Procedures of licensing, preparing licensing documents; Management of technology licensing process

**UNIT-6: Technology Takers and Entrepreneurship**

Meaning; types of technology takers; Technology Taking as a Strategy; Types of entrepreneurship– agripreneurs, startups, small businesses, Producer Organizations, Self Help Groups, Clusters and other forms of entrepreneurship.

**UNIT-7: Policy support for Technology Commercialization & Entrepreneurship Development**

**Policy support for entrepreneurship development in India** - National Policy on Skill Development and Entrepreneurship and other polices; Government of India Support for Innovation and Entrepreneurship– Startup India, Make in India, Digital India, Atal.

Innovation Mission and others; Entrepreneurship policy and schemes at different states of India; Organizations promoting entrepreneurship in India.

**BLOCK 4: TECHNOLOGY INCUBATION**

**UNIT-1: Basics of Technology Incubation**

Meaning, functions and types; stakeholder oriented incubation process– Livelihood incubation, village incubators.

**UNIT-2: Technology Incubation in India**

**System of technology incubation**- incubation process; its effectiveness; Managing profit oriented and non-profit incubators; Schemes for promoting incubators in India

**BLOCK 5: TECHNOLOGY PROMOTION AND ESSENTIAL SKILLS FOR TECHNOLOGY COMMERCIALISATION**

**UNIT-1: Technology Promotion**

**Technology promotion**– meaning, types, business meetings, scientist-industry/ entrepreneur meets, technology conclave, business plan competition, farmers' fairs, technology shows

**UNIT-2: Dealing with Entrepreneurs, Agripreneurs and Other Stakeholders**

Business communication; Business Etiquette; business networking

**BLOCK 6: EMERGING APPROACHES IN TECHNOLOGY COMMERCIALISATION AND INCUBATION**

**UNIT-1: Technology Scouting**

Technology Scouting and Innovations in technology incubation.

**PRACTICAL**

1. Understanding the technology commercialization process– Visit to Technology commercialization unit of ICAR Institute/ Agricultural University;
2. Understanding the IPR protection practices– Visit to Patent Attorney office;
3. Hands-on experience in drafting IPR application– Patent/Copyright/ Trademark;
4. Understanding protection of biological resources including plant varieties– Visit to PPVFRA Branch office/ ICAR Institute or Agricultural University involved in plant variety protection;
5. Documenting Traditional and indigenous knowledge – Field experience in using various protocols of using traditional and indigenous knowledge;
6. Protecting unique local goods through Geographical Indications – Hands on experiences in documenting and registering Geographical indications;
7. Technology assessment/ validation of traditional and indigenous knowledge – QuIK and other methods;
8. Hands on experience in technology valuation;
9. Hands on experience in technology licensing process including drafting agreements;
10. Understanding the Technology Business Incubation– Visit to Agri Business Incubator or Technology Business incubator;
11. Hands on experience in planning and organizing technology promotion events;
12. Hands on experience in various techniques in business communication and Business etiquette.

**TEACHING METHODS/ACTIVITIES**

4. Lecture cum discussion
5. Cases
6. Class exercises
7. Assignment (Reading/Writing)s
8. Student's Book/Publication Review
9. Group Presentation

**SUGGESTED READINGS**

1. Bandopadhyay, D. 2018. Securing Our Natural Wealth: A Policy Agenda for Sustainable Development in India and for Its Neighbouring Countries. Singapore; Springer.
2. Ghosh,S, and Joshi A. 2017. Handbook for Non-Profit Incubator Managers. New Delhi: Deutsche Gesellschaftfür Internationale.
3. Gupta AK. 2016. Grassroots Innovation: Minds on the margin are not marginal minds. Gurgaon: Penguin Books.
4. ICAR.2018. ICAR Guidelines for Intellectual Property Management and Technology Transfer/Commercialization (Revised in 2018). Indian Council of Agricultural Research, New Delhi
5. Pandey N and Dharni K. 2014. Intellectual Property Rights. Delhi. PHI Learning Pvt. Ltd.
6. Sharma G and Kumar H. 2018.Intellectual property rights and informal sector innovations: Exploring grassroots innovations in India. The Journal of World Intellectual Property. 1-17.
7. Stevens AJ. 2016. Intellectual property valuation manual for academic institutions (Report No. CDIP/17/INF/4). Geneva: Committee on Development and Intellectual Property (CDIP).
8. WIPO and ITC. 2010. Exchanging Value– Negotiating Technology Licenses, A Training Manual. World Intellectual Property Organization (WIPO).

## EXT 621 EDUCATIONAL TECHNOLOGY AND INSTRUCTIONAL DESIGN 3(2+1)

**WHY THIS COURSE?**

Technology, digital media and mobile access have drastically changed how people learn. And the field of education is rapidly becoming a dynamic opportunity for interactive instruction. Today's curriculum developers and instruction designers, especially in the extension and RAS ecosystem, need to equip themselves with the continuous developments in both theory and practice of instructional design so as to create satisfying learning experiences. Similarly, knowledge and skilful use of social media and disruptive technologies like internet of everything (IOE), augmented reality, artificial intelligence, *etc.* makes this course essential for extension professionals who are expected to act as harbingers of change.

**AIM OF THIS COURSE**

The aim is to develop knowledgeable, responsive and effective teachers committed to educating diverse group of learners in a dynamic extension landscape. This course will help the learners to appreciate the role of technology in learning and how it can be integrated into instructional design to create engaging learning experience in both classroom and online learning environment. The course also aims to prepare the students as competent professionals employable in the extension and RAS providers both as specialized researchers as well as designers.
The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Educational Technology | 1. The Landscape of Educational Technology and Instructional Design |
| | | 2. Theories of learning |
| | | 3. Technology Enabled Learning |
| 2. | Instructional Design | 1. Theories and models of Instruction |
| | | 2. Creating Instruction |
| | | 3. Instructional Strategies |
| | | 4. Evaluating Instruction |
| | | 5. Trends in Instructional Design |

**COURSE OUTCOMES:** After successful completion of this course, the students are expected to be able to:

1. Develop a critical understanding of concepts of learning and education within the context of agricultural development;
2. Relate and apply learning theories and models to the development, design and evaluation of courses utilizing educational technology and instructional design;
3. Hone their skills to take up research work in analyzing and evaluating different learning systems, teaching-learning environments, competencies and learning outcomes;
4. Find placement opportunities in the industry for job profiles such as e-learning specialist, training officer, curriculum developer, instructional designer, education consultant, *etc.*

**THEORY**

**BLOCK 1: EDUCATIONAL TECHNOLOGY**

**UNIT-1: The Landscape of Educational Technology and Instructional Design**

**Understanding various terms**- educational technology, instructional design, instructional systems design, curriculum design, pedagogy, andragogy; Brief overview of the origin and evolution of ET and ID as theory and practice; what is the relevance of ET and ID relevant in extension and rural advisory services? Extensional professionals as instructional designers and architects of the learning experience.

**UNIT-2: Theories of Learning**

What is learning? Critical overview of **Behaviourism, Cognitivism, Constructivism and Complex learning theories***;* instructional designers and learning theories; Types of learning or learning domains- Bloom's taxonomy of the cognitive domain, Krathwohl and Bloom's affective domain and Simpson's psychomotor domain

**UNIT-3: Technology Enabled Learning**

What is the role of technology in education? Digital media, new tools and technology; Open and distance Learning (ODL); **Online Education** - Synchronous and Asynchronous learning models; eLearning, Massive Open Online Courses - SWAYAM, Open Education Resources (OERs), Course CERA, Edu Ex, CoL, RLOs; **digital education and its applications in higher agricultural education**; Smart classrooms and Campuses, Web-based remote laboratory (WBRL); **Integrating media and digital tools into ID**; types and implications of disruptive technologies for higher education and extension; Augmented learning; Adaptive learning; meaning, features and good practices in using open source Learning Management Systems (Moodle); Quality assurance and certification in e-learning.

**BLOCK 2: INSTRUCTIONAL DESIGN**

**UNIT-1: Theories and Models of Instruction**

Howard Gardner's Theory of Multiple Intelligences, David Kolb's Experiential Learning Cycle, Albert Bandura's Social Learning Theory, Rand Spiro's Cognitive Flexibility Theory and Its Application In eLearning, Wlodkowski's **Motivational Framework for Culturally Responsive Adult Learning**; ADDIE Model, Dick and Carey Model, **SAM Model, Bloom's Taxonomy**; integrating the theories of instruction into the practice of ID in extension and RAS ecosystem.

**UNIT-2: Creating Instruction**

Overview of planning, designing and implementing the curricula and learning experiences; **Needs Analysis**- meaning, approaches and steps; **Task and content analysis**- meaning, approaches, steps and techniques (topic analysis, procedural analysis, and the critical incident method); **Learner analysis**– meaning, importance and approaches, relevance of Maslow's Hierarchy of Needs and learning styles, Captive Audience *vs.* Willing Volunteers, Universal vs. user-centered design, Learner Analysis Procedures; **Writing learning objectives**: Meaning of Learning Goal and Learning Objectives; ABCDs of well-stated objectives; Setting goals, translating goals into objectives; Contextualizing ADDIE process within the Extension learning environment.

**UNIT-3: Instructional Strategies**

**Organizing content and learning activities**- scope and sequence of instruction; **Posner's levels of organizing** (Macro, Micro, Vertical, and Horizontal) and **structures of organizing** (content vs. media) instruction, **Gagne's events of instruction**, Edgar Dale's Cone of Experience; **Methods of Delivery**- classroom teaching, programmed instruction, synchronous and asynchronous modes of distance education; Changing role of a teacher in classroom and teaching competencies.

**UNIT-4: Evaluating Instruction**

Meaning of **Assessment, Measurement and Evaluation**; **Developing learner evaluations** and their reliability & validity; **assessment techniques for measuring change in knowledge, skill and attitude of learners**- Objective Test Items, Constructed-Response Tests, Direct Testing, Performance Ratings, Observations and Anecdotal Records, Rubrics, Portfolios, Surveys and Questionnaires, Self-Reporting Inventories, Interviews; Conducting learner evaluation pre-, during and post-instruction*;* **Formative and Summative Evaluation**- meaning, approaches and steps; Evaluating Learner Achievement and the Instructional Design Process; Evaluating the success of instruction; Performance appraisal of teachers.

**UNIT-5: Trends in Instructional Design**

Alternatives to ADDIE model- Rapid prototyping and constructivist ID, reflections on instructional design as science and as an art; Relating ID models and process in extension learning environment; political economy of higher education in developed and developing countries; University assessment and rating methods, returns from agricultural higher education; research in education and instructional design.

**PRACTICAL**

1. Exercises on preparation of the Analysis Report that includes the task/content analysis and learner analysis and the Design Plan includes learning objectives and corresponding instructional strategies and assessment items;
2. Prepare course outline and lesson plan with an appreciation for diverse learning styles based on temperament, gender, and cultural/ethnic differences and deliver a lecture for UG/PG students;
3. Assessing learning styles through Barsch and Kolb inventories;
4. Development and testing of survey instruments for evaluating learning outcomes/ competencies of students;
5. Development and testing of survey instruments for performance appraisal/ competency assessment of teachers;
6. Design an online e-learning module on a topic of interest as a capstone project - integrate and apply the knowledge and skills gained from the course for creating an effective learning experience for a target audience;
7. Designing and developing a theme based knowledge portals;
8. Exercises on designing an online course using open source LMS like moodle or EdX;
9. Select and evaluate or design for social al media;

10. Prepare a short research paper on recent theories and models of instructional design;
11. Interview an instructional designer of your choice and prepare a synthesis report about what job roles he/she perform, What ID processes does he or she use, challenges faced;
12. Develop a prototype for one of the lessons in your design plan using PowerPoint or a website builder such as Weebly to create the screens integrating multimedia content and various functionalities;
13. Field visit to a virtual learning/ augmented learning labs, e-learning labs, distance learning centres, *etc.*;
14. Hands-on practice with video-editing software, web conferencing and video conferencing solutions.

**TEACHING METHODS/ACTIVITIES**

1. Lectures & Videos
2. Individual and group assignments
3. Group discussion and debating
4. Enactive learning exercises
5. Case studies / Case analysis
6. Storyboarding
7. Guest Lectures
8. Field Visits
9. Capstone Project
10. Prototype development

**SUGGESTED READINGS**


1. Agarwal JC. 2007. Essentials of Educational Technology Innovations in Teaching – Learning. 2nd Ed. Vikas Publ. House.
2. Allen M. 2013. Leaving ADDIE for SAM: An Agile Model for Developing the Best Learning Experiences, https://www.alleninteractions.com/about
3. Anglin GJ (Ed.), 1995. Instructional technology: Past, present, and future. Englewood, CO: Libraries Unlimited.
4. Bandura A. 1977. Social learning theory. Englewood's Cliffs, NJ: Prentice-Hall
5. Bandura A. 2001. Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, 52, 1–26.
6. Britain S. 2004. A Review of Learning Design: Concept, Specifications and Tools. A report for the JISC E-learning Pedagogy Programme, May 2004.
7. Brown AH and Timothy DG. 2016. The essentials of instructional design: connecting fundamental principles with process and practice, Third edition, Routledge
8. Challa J and Reddy NM. 2008. Education Technology for Agricultural Sciences, NAARM,Rajendra Nagar, Hyderabad, Telangana, India.
9. David HJ. 2003. Learning to Solve Problems: An Instructional Design Guide.
10. Kolb D. 2014. Experiential learning: Experience as the source of learning and development (2nd ed.). Upper Saddle River, NJ: Prentice Hall.
11. Reiser RA. 2001. A History of Instructional Design and Technology: Part I: A History of Instructional Media. Educational Technology Research and Development, 49(1), 53-64.
12. Reiser RA. 2001. A History of Instructional Design and Technology: Part II: A History of Instructional Design. Educational Technology Research and Development, 49 (2), 57-67.
13. Spector JM. 2015. Foundations of educational technology: Integrative approaches and interdisciplinary perspectives. Routledge.
14. Wlodkowski, Raymond J. 2008. Enhancing adult motivation to learn : a comprehensive guide for teaching all adults, 3rd ed., The Jossey-Bass higher and adult education series.


## EXT 622 RISK MANAGEMENT AND CLIMATE CHANGE ADAPTATION 3 (2+1)

**WHY THIS COURSE?**

Present agriculture and allied sectors India face tremendous challenges on multiple fronts. Agrarian distress and the climate change impacts together pose grave dangers to food, nutritional and ecological security. As change agents, extensional professionals in particular and agricultural graduates in general need to quip themselves with knowledge and skill sets required to navigate the climate change scenario so as to help reduce risk and vulnerability. Hence, this customised course.

**AIM OF THIS COURSE**

The course is designed to provide both basic and applied knowledge on the subjects of risks management and climate change adaptation with reference to Indian agriculture. This course will approach the subjects from a multidisciplinary perspective - technical, socio-economic, political, financial, and regulatory. It aims to equip students to identify, evaluate and evolve ways to address (mitigate and manage) risks and climate change.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Risk Management in Agriculture | Understanding Risk and Distress<br>Managing Risk and Distress in Agriculture<br>Extension Professionals and Risk management |
| 2. | Adapting to Climate Change | Introduction to Climate Change Science<br>Introduction to Climate Change Adaptation and Mitigation<br>Climate Smart Agriculture and Extension Advisory Services |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Appreciate the scientific foundation of risk management and climate change science and relate the key learning to the job of an extension professional;
2. Utilise methods and tools for risk and climate related vulnerability assessments and adaptation strategies in the context of Indian agriculture/ farming scenario;
3. Utilise material in scientific publications relevant for risk management and climate change adaptation and critically reflect on their benefits and limitations for decision making.

**BLOCK 1: RISK MANAGEMENT IN AGRICULTURE**

**UNIT-I: Understanding Risk and Distress**

Introduction to risk, risk management, uncertainty, sensitivity and distress, General risk theory, Risk analysis methods, Risk perception and decision making, **Indicators of risk and distress in agriculture**– identification, selection and assessment, Understanding the **agrarian distress in Indian agriculture**, **Sources of distress in Indian farming** -changing farm size, land use, cropping patterns, pricing policy, markets and terms of trade, Typology of crisis in agriculture; Droughts, floods and Indian agriculture, Distress and farmer suicides - causes and socio-economic consequences.

**UNIT-II: Managing Risk and Distress**

**Ways to reducing/managing risk and distress in Indian agriculture**; crop and life insurance; Developing support systems; Planning, implementation and evaluation of risk/distress management programs; Institutional frameworks for risk and disaster management- NDMA & SDMAs; Developing District Agriculture Contingency Plans; Risk management by diversification; Good practices and lessons from other countries; Responses of government, non-government and extension system to agrarian crisis; National Farmers Policy.

**UNIT-III: Extension Professionals and Risk management**

**Understanding social-psychological and behavioural dimensions of farmers under risk/distress**; Risk perception and communication; **Helping farmers manage farm level risks** - mobilising resources, linking with markets, strengthening capacities; Working with village level risk management committees; **Operational skills** for preparing contingency and disaster management plans; Institutional and extension innovations in managing risk and distress; Policy and technological preferences for dealing with drought and flood.

**BLOCK 2: ADAPTING TO CLIMATE CHANGE**

**UNIT-I: Introduction to Climate Change Science**

Basic concepts of and terms in climate change science; impacts of climate change; anthropogenic drivers of climate change, Climate change and Indian agriculture; climate adaptation vs. disaster risk reduction; anticipated costs of adaptation; climate change and poor; Overview of UNFCCC framework and institutions, Kyoto Protocol and beyond; India's National Action Plan on Climate Change and National Mission on Strategic Knowledge on Climate Change; National Coastal Mission, Institutional arrangements for managing climate change agenda.

**UNIT-II: Introduction to Climate Change Adaptation and Mitigation**

Introduction to Climate Change Adaptation, Conducting a vulnerability assessment (CVI and SEVI frameworks), Identifying and selecting adaptation options; Global, national and state level initiatives and plans to support climate change adaptation, private sector and civil society initiatives and activities; Mainstreaming climate change adaptation into development planning, Financing climate adaptation and budgetary allocations for programmes, Gender and climate change adaptation, Agricultural development programmes and strategies towards climate change adaptation and mitigation, Community based and Ecosystem based adaptation strategies, preparing evidence based intervention plans for vulnerability reduction at micro and macro-levels.

**UNIT-III: Climate Smart Agriculture (CSA) and Extension &Advisory Services**

**Climate Smart Agriculture**; Developing climate smart and climate resilient villages; Stakeholders and determinants involved in climate smart agriculture; Climate smart agriculture and EAS; Innovative extension approaches used in CSA; Climate information services, Farmers perceptions about climate change; Farm and household level manifestations and adaptation strategies; Barriers and limits to adaptation; Farmers feedback on performance of extension methods; Skills, competencies and tools required for extension professionals at different levels and development departments in up scaling CSA.

**PRACTICAL**

1. Hands-on practice in using risk assessment/analysis tools;
2. Case studies on risk / distress assessment in agriculture -Indian and global;
3. Lessons / Experiences from NICRA Project in agriculture and allied sectors;
4. Developing criteria, indicators and indices for assessment of risk, vulnerability and resilience;
5. Hands on practice on use of vulnerability and risk assessment tools and techniques;
6. Case studies on success stories of climate change adaptation and community based initiatives;
7. Developing district and village level intervention plans for climate change adaptation;
8. Field Visits to State Disaster Management Authority;
9. Case studies on climate smart agriculture / villages from India and world;
10. Case studies on impact assessment of crop insurance programs, disaster management programs;
11. Capstone project on documenting ITKs and local practices related to reducing risk/ climate resilience agriculture.

**TEACHING METHODS / ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)s
- Student's Book/Publication Review
- Student presentation
- Group Work
- Student's interview of key policy makers
- Case Analysis and case studies Guest Lectures
- Review of policy documents

**SUGGESTED READINGS**

1. Coppola DP. 2011. Introduction to International Disaster Management. (2. ed.). Amsterdam: Elsevier, 2011. Ch 2: Hazards, pp. 37-137; Ch 3: Risk and Vulnerability, pp. 139-207; Ch 4: Mitigation, pp. 209-250; Ch 5: Preparedness, pp. 251-303.
2. Davis K and Sulaiman RV. 2013. Extension Services for Effective Agricultural Risk Management. CRISP. Washington, DC: FARMD.
3. GIZ. 2015. Capacity Development for Climate Change Adaptation and Mitigation. A Training Manual- 2014. Deutsche Gesellschaft fürInternationale Zusammenarbeit and National Bank for Agriculture and Rural Development.

4. Kahan D. 2008. Managing Risk in Farming. Farm management extension guide Live and Learn Environmental Education. 2011. Farm technology- Protecting food security through adaptation to climate change in Melanesia.
5. Mall, Rajesh, Singh R, Gupta A, Srinivasan G and Rathore L. 2007.Impact of climate change on Indian agriculture: a review. Climatic Change. 82. 225-231. 10.1007/s10584- 006-9236-x. MANAGE, Climate change and its Impact on Agriculture.
6. Morris HLC, Megalos MA, Vuola AJ, Adams DC and Monroe MC. 2014.Cooperative Extension and Climate Change: Successful Program Delivery. Journal of Extension, Volume **52(2).**
7. Rao RCA. 2018. Climate Change Impacts, Adaptation and Policy Preferences: A Snapshot of Farmers' Perceptions in India. Policy Paper 01/2018. ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, India. 34 P
8. Rupan R, Saravanan R. and Suchiradipta B. 2018.Climate Smart Agriculture and Advisory Services: Approaches and Implication for Future. MANAGE Discussion Paper 1, CAEIRA, MANAGE, Hyderabad, India
9. Sharma AP, Joshi KD, Naskar M, and DasMK. 2015.Inland fisheries & climate change: vulnerability and adaptation options, ICAR-CIFRI Special Publication ISSN 0970-616X Policy Paper No.: NICRA/Policy/2015-16/1.
10. Singh NP, Arathy A, Pavithra S, Balaji SJ, Bhawna A and Arshad MK. 2017. Mainstreaming Climate Change Adaptation into Development Planning. Policy Paper 32. ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi.
11. Smit B and Skinner MW. 2002.Adaptation options in agriculture to climate change: a typology. *Mitigation and adaptation strategies for global change*, *7*(1), pp.85-114.
12. Srinivasrao CH. 2018. Agro-ecosystem based sustainability indicators for climate resilient agriculture in India: A conceptual framework, July 2018, Ecological Indicators, DOI: 10.1016/j.ecolind.2018.06.038


## EXT 623 LIVELIHOOD DEVELOPMENT 2 (1+1)

**WHY THIS COURSE?**

One of the aims of extension work is to enhance and expand the sustainable livelihood opportunities for individuals in a society. For this a thorough understanding of the different aspects of livelihood and its interface with nature becomes imperative. Resource poor farmers and the socially and politically weaker sections of the society currently face several challenges in expanding their livelihoods. Keeping these in view, the course has been designed to provide a theoretical framework for understanding of the basic concepts, definitions and approaches related to 'livelihood', 'vulnerability' 'institutional processes', and 'development and policies' pertaining to livelihood development in India.

**AIM OF THIS COURSE**

- To develop an understanding on the concept of livelihood and its various forms;
- To acquaint the students regarding the various alternative approaches that has been adopted to support livelihoods;
- To familiarize the students to some of the methods, tools and techniques they can utilize to design livelihood interventions;
- To expose the students to the context, especially the economic models and policy environment that guides the livelihood choices;
- To equip students to work in multidisciplinary teams and engage at multiple levels on livelihood issues.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Understanding of Livelihood | 1. Concept of Livelihoods |
| | | 2. Livelihood Challenges |
| 2. | Livelihood Analysis | 1. Livelihoods framework |
| | | 2. Designing livelihood intervention and promotion |
| 3. | Livelihood Augmentation | 1. Pathways for LA |

**COURSE OUTCOMES**

This course will equip students with perspectives, knowledge and skills to develop a comprehensive understanding of the livelihood concepts, various forms, approaches, tools and techniques to analyze existing livelihood pattern and strategies the sustainable livelihood intervention in the rural areas.

**THEORY**

**BLOCK 1: UNDERSTANDING OF LIVELIHOOD**

**UNIT-I: Concept of Livelihoods**

Basic concepts of livelihood and Development, **Types of development**-Immanent/inherent and interventionist/ intentional; Why promote livelihood; **Livelihood intervention**: definition, types- Spatial, segmental, sector –sub-sector; Systemic view of Livelihoods, **Understanding Rural Livelihoods**- Farm, Non-Farm, and off farm; Linkages with Farm and Off-farm Livelihoods; **Economic Models.**

**UNIT-II: Livelihood Challenges**

**Livelihood Challenge**- Political economy of Livelihoods, Issues of access to farm and non- farm livelihoods; **Livelihoods from a Gender Perspective**-Feminization of agriculture/ poverty, women in the unorganized sector, the issue of unpaid and informal work; **Livelihood Coping Mechanism**- Climate Change and Livelihoods; Livelihoods and Disasters.

**BLOCK 2: LIVELIHOOD ANALYSIS**

**UNIT-I: Livelihood Frameworks**

**Sustainable Livelihoods Approaches (SLAs)**-Definition and origins of SLA; Assets or capitals and capabilities in SLA and its linkage to the other capitals: Physical, Social, Economic, Human, Natural; **Vulnerability Assessment**- Shocks, trends, seasonality; Policies, institutional context and processes; **Conceptual Frameworks**-DFID, CARE, UNDP, OXFAM, BASIX livelihood triad, Nine square Mandala or Rural Livelihood System's Framework, *etc.*; Past, Present and possibilities for the future of the SLA, critiques of the approach.

**UNIT-II: Designing Livelihood Intervention and Promotion**

**Designing a suitable livelihood intervention**- Observing and Understanding the Local Economy; Selecting livelihood activities suitable for the poor in the area; Deciding on the interventions. **Livelihood promotion approaches**- Poverty and livelihood: Approaches and programs in India; Livelihood and a Rights Based Approach-MGNREGA and its critique; Livelihood and a Social Capital based approach: NRLM.

**BLOCK 3: LIVELIHOOD AUGMENTATION (LA)**

**UNIT-I: Pathways for LA**

Basic concepts; Pathways: a) Entrepreneurial strategies for LA; b) NRM based intervention; c) Market based interventions including Value-chain analysis; d) ICT based interventions; e) Livelihood and allied agriculture (dairy, poultry, Goatery, *etc.*) based livelihood; f) Forest based Livelihoods vis a vis Livelihood Protection and Promotion: Contribution of NTFP in supporting rural livelihoods.

**Note:** Block 'A' and 'B' is theoretical; Block 'C' should be covered in the form practical's supported by few classroom discussion through cases.

**PRACTICAL**

1. Village stays to understand the livelihood pattern of villagers and how the other socio-economic factors affect the livelihood of people;
2. Visit to institutes/ universities adopted and/or nearby villages to experience the life and natural resources in rural communities-understanding of village culture, evolution, social structure, livelihood pattern, trends, governance arrangements, and the natural context (landscape layout, land use, vegetation types *etc.*);
3. Application of participatory rural appraisal skills for understanding village context; Engagement of working with rural communities and their grass-root institutions, understanding dynamics of working in a group;
4. Visit to different agri-business models as mentioned in the Block 'C'. Group assignments may be given to document the field experience in the form of case study of an enterprise/ entrepreneur/ members and other related stakeholders.

**TEACHING METHODS/ACTIVITIES**

- Interactive Lectures– by sharing in advance a reading material.
- Analysis of case studies.
- Audio-visual of successful/ failure models of agribusiness firms.
- Guest session by field practitioners, if possible.
- Group presentations by the students.
- Field visit and field based individual or group assignments.

**SUGGESTED READINGS:**

1. Anonymous. 2010. State of India's Livelihood Report. Edited by Sankar Datta and Vipin Sharma. Sage Publications, New Delhi.
2. Carney D, Drinkwater M, Rusinow T, Neefjes K, Wanmali S and Singh N. 1999. Livelihoods approaches compared: A brief comparison of the livelihoods approaches of the UK Department for International Development (DFID), CARE, Oxfam and the United Nations Development Programme (UNDP).
3. Desai RM and Joshi S. 2014. Can Producer Associations Improve Rural Livelihoods? Evidence from Farmer Centres in India, The Journal of Development Studies, 50 (1): 64-80.
4. Ellis F. 2012. Rural Livelihoods and Diversity in Developing Countries, Oxford.
5. Mahajan V, Datta S and Thakur G. 2009.A Resource Book for Livelihood Promotion, The Livelihood School, BASIX, Hyderabad.
6. Morse S and McNamara N. 2009. Sustainable Livelihood Approach: A critique of theory and practice, Springer Science. (Chapter 2)
7. Pastakia A and Oza S. 2011. Livelihood Augmentation in Rainfed Areas: A Strategy Handbook for the Practitioner, Development Support Centre, Ahmedabad.
8. Scoones Ian. 1998. Sustainable Rural Livelihoods: A Framework for Analysis, IDS Working Paper 72.
9. Scoones Ian. 2009. Livelihoods perspectives and rural development. Journal of Peasant Studies, 36(1).

## EXT 624 FACILITATION FOR PEOPLE CENTRIC DEVELOPMENT 3 (2+1)

**WHY THIS COURSE?**

The prime aim of the agricultural extension professionals is to influence development change among the stakeholders with whom they work. In the Agricultural Innovation Systems (AIS) context, this change will happen when good relationships, networks and partnerships are formed. A new extension approach that aims at participatory and group learning as well as networking, where the extensionist acts as a facilitator is needed. It is important to inculcate the good facilitation skills by the extension professional to increase the effectiveness and impact among the agricultural extension and advisory services stakeholders.

**AIM OF THIS COURSE**

1. To orient students on the importance facilitation;
2. To inspires students to understand facilitation tools to influence change at the individual, group and organizational levels;
3. To develop capacities in multi-stakeholder engagement, facilitation and networking.

The course is organized as follows:

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Introduction to Facilitation for Development | 1. Facilitation for Development in the AIS |
| | | 2. Principles, Attributes and Skills for Facilitation for Development |
| 2. | Facilitating change in individuals, groups and organizations | 1. Realize Potential- Self-Discovery |
| | | 2. Group Dynamics and Working Together |
| | | 3. Organizational Change Process |
| 3. | Facilitating operational level multi-stakeholder engagements | 1. Multi-Stakeholder Interactions |
| | | 2. Innovation and Policy Engagement Platforms |
| 4. | Brokering strategic partnerships, networking and facilitation | 1. Linkages, Partnerships, Alliances and Networking |

| | | |
|---|---|---|
| | | 2. Facilitating Capacity Development |

**COURSE OUTCOMES**

After successful completion of this course, the students are expected to be able to:

1. Appreciate the importance of facilitation skills and tools.
2. Understand facilitation and networking techniques.
3. Critically evaluate strategic partnerships and linkages.
4. How to manage group dynamics and engage multi-stakeholders and virtual platforms.

**THEORY**

**BLOCK 1: INTRODUCTION TO FACILITATION FOR DEVELOPMENT**

**UNIT-I: Facilitation for development in the AIS**

Facilitation for development in the AIS; Understanding facilitation for development; Importance of facilitation as a core function of extension within the Agricultural Innovation Systems (AIS)

**UNIT-II: Principles, Attributes and Skills for Facilitation for Development**

Basic principles of facilitation for development; Desired attributes of facilitator for development- Cognitive attributes, Emotional attributes (Emotional intelligence), Social, behavioural and attitudinal attributes; Technical skills of a facilitator for development- Design processes, Facilitation techniques and tools, the art of questioning and probing, Process observation and documentation, Visualization.

**BLOCK 2: FACILITATING CHANGE IN INDIVIDUALS, GROUPS AND ORGANISATIONS**

**UNIT-I: Realise Potential- Self-Discovery**

Self-discovery to realize our potentials, Tools for self-discovery, formulating a personal vision, Taking responsibility for your own development.

**UNIT-II: Group Dynamics and Working Together**

Understanding the dynamics of human interaction, Group dynamics and power relations, Managing relationships, Shared vision and collective action, Tools for team building.

**UNIT-III: Organizational Change Process**

Organizational change process, Organizational learning to adapt to changing environments, Enhancing performance of organizations, Leadership development, Tools for organizational change.

**BLOCK 3: FACILITATING OPERATIONAL LEVEL MULTI-STAKEHOLDER ENGAGEMENTS**

**UNIT-I: Multi-Stakeholder Interactions**

Defining stakeholders, Development of collective and shared goals, Building trust and accountability, Tools for stakeholder identification and visioning.

**UNIT-II: Innovation and Policy engagement Platforms**

Visualizing innovation platforms (IPs), Why are IPs important?, Different models of IPs for multi-stakeholder engagement, policy engagement platforms, Generating issues and evidence for policy action, Advocacy for responsive policy processes.

**BLOCK 4: BROKERING STRATEGIC PARTNERSHIPS, NETWORKING AND FACILITATION**

**UNIT-I: Linkages, Partnerships, Alliances and Networking**

Brokering linkages and strategic partnerships, Identification of critical links, Knowledge brokering, Creating linkages with markets, Learning alliances and networking, Coordination of pluralistic service provision within the AIS, The concept of action learning and reflective practitioners, Networking.

**UNIT-II: Facilitating Capacity Development**

**Facilitating Capacity Development-**Facilitate participation and learning in development programs and projects. **Virtual platforms-** skills for strengthening dialogue, collaboration, shared commitment amongst diverse actors and stakeholders.

**PRACTICAL**

1. Practicing facilitation techniques;
2. Self discovery exercises;
3. Working together and interaction (task based);

4. Arrangement for multi-stakeholder interactions;
5. Understanding organizational change process tools and techniques;
6. Case analysis on organizational change process;
7. Participating with innovation platforms;
8. Policy engagement platforms;
9. Stakeholder analysis mapping;
10. Exercise on networking skills;
11. Facilitating capacity building programmes;
12. Facilitating virtual platforms;
13. Filed visit to multi-stakeholder partnership projects.

**TEACHING METHODS/ACTIVITIES**

- Lecture
- Assignment (Reading/Writing)s
- Student's Book/Facilitation Manual/Publication Review
- Student presentation
- Group Work
- Student's interview with facilitators
- Case Analysis
- Guest Lectures
- Review of facilitation methodologies
- Short internships

**Suggested Readings:**


1. Clarke S, Blackman R and Carter I. 2004. Facilitation skills workbook -Training material for people facilitating small group discussions and activities using PILLARS Guides. Tearfund, England.
2. Davis S. 2014. Using the Socratic Method as a Learning Facilitator https://facilitatoru.com/training/using-the-socratic-method-as-a-learning-facilitator/
3. Hanson L. and Hanson C. 2001. Transforming participatory facilitation: Reflections from practice.
4. Jost C, Alvarez S and Schuetz T. 2014.CCAFS Theory of Change Facilitation Guide. CGIAR Research Program on Climate Change, Agriculture and Food Security.
5. Kennon N., Howden P. and Hartley M. 2002.Who really matters? A stakeholder analysis tool. Extension Farming Systems Journal: 5(2).
6. Krick T, Forstater M, Monaghan P,Sillanpaa M. 2005. The Stakeholder Engagement Manual: Volume **2**, the Practitioner's Handbook on Stakeholder Engagement. Accountability, United Nations Environment Programme, Stakeholder Research Associates Canada Inc.
7. Linden J. 2015. Innovation in Layer Housing: From Drawing Board to Reality.
8. Makini FW, Kamau GM, Makelo MN, Adekunle W, Mburathi GK, Misiko M, Pali M, and Dixon J.2015. Operational Field Guide for Developing and Managing Local Agricultural Innovation Platforms.Australian Centre for International Agricultural Research
9. Mind Tools. 2005. The Role of a Facilitator-Guiding an Event through to a Successful Conclusion. https://www.mindtools.com/pages/article/RoleofAFacilitator.htm
10. Mittal N, Sulaiman RV and Prasad RM. 2016.Assessing Capacity Needs of Extension and Advisory Services A Guide for Facilitators. Agricultural Extension in South Asia.
11. Mulema, A.A. 2012. Organisation of innovation platforms for Agricultural Research and Development in the Great Lakes Region of Africa. Graduate Theses and Dissertations. Paper12631.
12. Nederlof S, Wongtschowski M and Van der Lee (eds.) 2011.Putting Heads Together- Agricultural Innovation Platform in Practice.KIT Publishers.
13. NgwenyaH, and Kibwika P, 2016. NELK Module 7 Introduction to Facilitation for Development, New Extensionist Learning Kit (NELK), Global Forum for Rural Advisory Services (GFRAS).

# DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY AGRICULTURE UNIVERSITY JODHPUR

### Semester Wise Course Title and Credits: M.Sc. (Agri.) Soil Science

| S.No. | Course No. | Credit hours | Course Title |
|---|---|---|---|
| **Semester I** | | | |
| 1. | SOIL 511* | 3(2+1) | Soil Chemistry |
| 2. | SOIL 512* | 3(2+1) | Soil Mineralogy, Genesis and Classification |
| 3. | SOIL 513** | 2(0+2) | Analytical Technique and Instrumental Methods in Soil and Plant Analysis |
| **Semester II** | | | |
| 4. | SOIL 521* | 3(2+1) | Soil Fertility and Fertilizer Use |
| 5. | SOIL 522* | 3(2+1) | Soil Physics |
| 6. | SOIL 523** | 3(2+1) | Soil Biology and Biochemistry |
| 7. | SOIL 524# | 3(2+1) | Soil Erosion and Conservation |
| 8. | SOIL 525# | 2(1+1) | Soil Survey and Land Use Planning |
| **Semester III** | | | |
| 9. | SOIL 531** | 3(2+1) | Remote Sensing and GIS Technique for Soil and Crop Studies |
| 10. | SOIL 532# | 3(2+1) | Soil, Water and Air Pollution |
| 11. | SOIL 533# | 1(1+0) | Land Degradation and Restoration |
| 12. | SOIL 534# | 2(1+1) | Management of Problematic Soils and Water |
| 13. | SOIL 535# | 3(2+1) | Introduction to Nanotechnology |
| 14. | SOIL 536# | 2(1+1) | Radioisotopes in Soil and Plant Studies |
| 15. | SOIL 591 | 1(1+0) | Master's Seminar |
| **Semester IV** | | | |
| 16. | SOIL 598 | NC | Comprensive Examinations |
| 17. | SOIL 599@ | 30 | Master's Research |

[*Core Courses **Compulsory Courses, #Optional Courses as per Advisory/Departmental Committee, NC-Non-Credit Course, @Credit load of Master's Research (SOIL 599) shall be depending upon Advisory committee)].

### Courses requirements: M.Sc. (Agri.) Soil Science

| Particulars | M.Sc. (Agri) Soil Science |
|---|---|
| Compulsory courses (Core and Major) | SOIL 511, SOIL 512, SOIL 513, SOIL 521, SOIL 522, SOIL 523, SOIL 531 |
| Optional courses | SOIL 524, SOIL 525, SOIL 532, SOIL 533, SOIL 534, SOIL 535, SOIL 536 |
| Minor & supporting Courses* | PP 513, PP 522, AGRON 531, STAT 512, STAT 521 |
| Non-Credit compulsory Courses | PGS 501, PGS 502, PGS 503, PGS 504 and PGS 505 |
| Comprehensive (Non-Credit) | SOIL 598 |
| Seminar | SOIL 591 |
| Thesis/Research | SOIL 599 |
| Deficiency courses | As deemed suitable by advisory committee, if any |

*Suggested by Advisory Committee.

### Semester wise break-up of credit hours M.Sc. (Agri.) Soil Science

| Semester | Major Course (Credit) | Minor Course (Credit) | Supporting Course (Credit) | Non-Credit Compulsory Courses* | Seminar |
|---|---|---|---|---|---|
| I | 3 (8) | 1 (3) | 1 (3) | 3 (3) | - |
| II | 3 (9) | 1 (3) | 1 (3) | 2 (2) | - |
| III | 2 (6) | 1 (3) | - | - | 1 |

| | | | | | |
|---|---|---|---|---|---|
| IV | - | - | - | - | - |

**Note:** No. of credit hours/courses may be increased as per the choice of courses suggested by Advisory Committee of the students. *PGS Courses (Non-Credit compulsory Courses) shall be compulsory for M.Sc. (Agri.) Soil Science Students.

**Examination pattern as per BSMA Report:**

| Particulars | Quiz/ Assignment | Mid Term | Final Examination | |
|---|---|---|---|---|
| | | | Theory | Practical |
| Courses with Theory & Practical | 5 | 15 | 50 | 30 |
| Courses with only Theory | 5 | 15 | 80 | - |
| Courses with only Practical | 5 | 15 | - | 80 |

**Pattern of Comprehensive Exam of M.Sc. (Agri.) Soil Science:**

The pattern will be of Written Exam followed by Oral Exam:

**(i.) Written Exam:**

M.Sc. (Agri.): 2 papers (1 Major + 1 Supporting & Minor subject)

Maximum marks: 100 each

Paper setting: Internal under the Chairmanship of HOD.

Evaluation: Internal under the Chairmanship of HOD.

Qualifying marks: M.Sc. (Agri.): 60% individually.

**(ii.) Oral Exam: 100 marks**

M.Sc. (Agri.): After qualifying the Written Exam, the Oral Exam should be conducted by the Students' Advisory Committee in presence of HOD.

Grading of the Comprehensive Exam (M.Sc.): Satisfactory/ Not Satisfactory.

# COURSES CONTENT: M.Sc. (Agri.) SOIL SCIENCE

**SOIL 511 SOIL CHEMISTRY 3(2+1)**

## OBJECTIVE

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

## COURSE OUTCOME

After completition of course student will have experience on the knowledge of chemical behaviour of soil and their utility in research for solving field problem.

## THEORY

**UNIT-I:** Chemical (elemental) composition of the earth's crust, soils, rocks and minerals.

**UNIT-II:** Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

**UNIT-III:** Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter- fractionation of soil organic matter and different fractions, Characterization of OM; clay organic interactions.

**UNIT-IV:** Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr- Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange –inner sphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresisin sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC,CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

**UNIT-V:** Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; Concept of quantity/ intensity (Q/I) relationship; step and constant-rate K; management aspects.

**UNIT-VI:** Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

**UNIT-VII:** Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.

**UNIT-VIII**: Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry

## PRACTICAL

1. Preparation of saturation extract, measurement of pH, EC, CO3, HCO3, Ca, Mg, K and Na, Determination of CEC and AEC of soils,
2. Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter,
3. Determination of point of zero charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances,
4. Potentiometric and conducto-metric titration of soil humic and fulvic acids,(E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the D (E4/E6) values at two pH values,
5. Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved,
6. Determination of titratable acidity of an acid soil by BaCl2-TEA method,
7. Determination of Q/I relationship of potassium,
8. Determination of lime requirement of an acid soil by buffer method,
9. Determination of gypsum requirement of an alkali soil.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**


1. Bear RE. 1964. Chemistry of the Soil. Oxford and IBH.
2. Bolt GH and Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.
3. Greenland DJ and Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & Sons.
4. Greenland DJ and Hayes MHB. Chemistry of Soil Constituents. John Wiley & Sons.
5. McBride MB. 1994. Environmental Chemistry of Soils. Oxford Univ. Press.
6. Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford Univ. Press.
7. Sposito G. 1984. The Surface Chemistry of Soils. Oxford Univ. Press.
8. Sposito G. 1989. The Chemistry of Soils. Oxford Univ. Press.
9. Stevenson FJ. 1994. Humus Chemistry. 2nd Ed. John Wiley & Sons.
10. Van Olphan H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.


## SOIL 512 SOIL MINERALOGY, GENESIS AND CLASSIFICATION 3(2+1)

**OBJECTIVE**

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

**COURSE OUTCOME:** After completition of course student will have experience on the knowledge of soil taxonomy and genesis and their utility in research for solving field problem.

**THEORY**

**UNIT-I:** Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

**UNIT-II:** Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; Clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

**UNIT-III:** Factors of soil formation, soil formation models; soil forming processes; Weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

**UNIT-IV:** Concept of soil individual; soil classification systems–historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps–usefulness.

**PRACTICAL**

1. Separation of sand, silt and clay fraction from soil.
2. Determination of specific surface area and CEC of clay
3. Identification and quantification of minerals in soil fractions.
4. Morphological properties of soil profile in different land forms.
5. Classification of soils using soil taxonomy.
6. Calculation of weathering indices and its application in soil formation
7. Grouping soils using available data base in terms of soil quality.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**


1. Brady NC & Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
2. Buol EW, Hole ED, MacCracken RJ and Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ.
3. Dixon JB and Weed SB. 1989. Minerals in Soil Environments. 2nd Ed. Soil Science Society of America, Madison.

4. Grim RE. 1968. Clay Mineralogy. McGraw Hill.
5. Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
6. Sehgal J. 2002. Introductory Pedology: Concepts and Applications. New Delhi
7. Sehgal J. 2002. Pedology - Concepts and Applications. Kalyani.
8. USDA. 1999. Soil Taxonomy. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.
9. Wade FA and Mattox RB. 1960. Elements of Crystallography and Mineralogy. Oxford & IBH.
10. Wilding LP and Smeck NE. 1983. Pedogenesis and Soil Taxonomy: II. The Soil Orders. Elsevier.
11. Wilding NE and Holl GF. (Eds.). 1983. Pedogenesis and Soil Taxonomy: I.

## SOIL 513 ANALYTICAL TECHNIQUE AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS 2(0+2)

**OBJECTIVE**

To familiarize the students with commonly used instruments– their working, Preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

**COURSE OUTCOME:** After completition of course student will have confidence for setting soil testing laboratory.

**PRACTICAL**

**UNIT-I:** Preparation of solutions for standard curves, indicators and standard solutions for acid base, oxidation reduction and complex ometric titration; soil, water and plant sampling techniques, their processing and handling.

**UNIT-II:** Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

**UNIT-III:** Principles of visible, ultraviolet and infrared spectro-photometery, atomic absorption, flame- photometry, inductively coupled plasma spectrometry; chromatographic techniques, massspectrometry and X-ray defractro-metery; identification of minerals by X-ray by different methods, CHNS analyser.

**UNIT-IV:** Electrochemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

**UNIT-V:** Wet digestion/fusion/extraction of soil with aquaregia with soil for elemental analysis; triacid/di-acid digestion of plant samples; determination of available and total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in soils; determination of total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in plants.Qualitative analysis for irrigation water quality.

**UNIT-VI:** Drawing normalized exchange isotherms; measurement of redox potential.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching and laboratory practicals.

**SUGGESTED READINGS**

1. Hesse P. 971. Textbook of Soil Chemical Analysis. William Clowes & Sons.
2. Jackson ML. 1967. Soil Chemical Analysis. Prentice Hall of India.
3. Keith A Smith 1991. Soil Analysis; Modern Instrumental Techniques. Marcel Dekker.
4. Kenneth Helrich 1990. Official Methods of Analysis. Association of Official Analytical Chemists.
5. Page AL, Miller RH and Keeney DR. 1982. Methods of Soil Analysis. Part II. SSSA, Madison.
6. Piper CE. Soil and Plant Analysis. Hans Publ.
7. Singh D, Chhonkar PK and Pandey RN. 1999. Soil Plant Water Analysis – A Methods Manual. IARI, New Delhi.
8. Tan KH. 2003. Soil Sampling, Preparation and Analysis. CRC Press/Taylor & Francis.
9. Tandon HLS. 1993. Methods of Analysis of Soils, Fertilizers and Waters. FDCO, New Delhi.
10. Vogel AL. 1979. A Textbook of Quantitative Inorganic Analysis. ELBS Longman.
11. Chahar S., Sodani R. and Yadav S. 2017. Manual for soil and plant analysis. Lambert pub.

## SOIL 521 SOIL FERTILITY AND FERTILIZER USE 3(2+1)

**OBJECTIVE**

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

**COURSE OUTCOME**

After completition of course student will have experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

**THEORY**

**UNIT-I:** Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources– fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients- functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity;

**UNIT-II:** Soil and fertilizer nitrogen– sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

**UNIT-III:** Soil and fertilizer phosphorus- forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers- behaviour in soils and management under field conditions. Potassium- forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

**UNIT-V:** Sulphur- source, forms, fertilizers and their behaviour in soils; role in crops and human health; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

**UNIT-VI:** Micronutrients– critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

**UNIT-VII:** Common soil test methods for fertilizer recommendations; quantity–intensity relationships; soil test crop response correlations and response functions.

**UNIT-VIII:** Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; speciality fertilizers concept, need and category. Current status of speciality fertilizers use in soils and crops of India.

**UNIT-IX:** Soil fertility evaluation- biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, Determination of critical limit, DRIS

**UNIT-X:** Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.

**PRACTICAL**

1. Soil and plant sampling and processing for chemical analysis
2. Determination of soil pH, total and organic carbon in soil
3. Chemical analysis of soil for total and available nutrients (major and micro)
4. Analysis of plants for essential elements(major and micro)

**TEACHING METHODS/ACTIVITIES**

Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
2. Kabata-Pendias A and Pendias H. 1992. Trace Elements in Soils and Plants. CRC Press.
3. Kannaiyan S, Kumar K and Govindarajan K. 2004. Biofertilizers Technology. Scientific Publ.
4. Leigh JG. 2002. Nitrogen Fixation at the Millennium. Elsevier.
5. Mengel K and Kirkby EA. 1982. Principles of Plant Nutrition. International Potash Institute, Switzerland.

6. Mortvedt JJ, Shuman LM, Cox FR and Welch RM. 1991. Micronutrients in Agriculture. 2nd Ed. SSSA, Madison.
7. Pierzinsky GM, Sims TJ and Vance JF. 2002. Soils and Environmental Quality. 2nd Ed. CRC Press.
8. Stevenson FJ and Cole MA. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients. John Wiley & Sons.
9. Tisdale SL, Nelson SL, Beaton JD and Havlin JL. 1999. Soil Fertility and Fertilizers. 5th Ed. Prentice Hall of India.
10. Troeh FR and Thompson LM. 2005. Soils and Soil Fertility. Blackwell.

## SOIL 522 SOIL PHYSICS 3(2+1)

**OBJECTIVE**

To impart basic knowledge about soil physical properties and processes in relation to plant growth.

**COURSE OUTCOME:** After completition of course student will have experience on the knowledge of soil physical properties and processes in relation to plant growth.

**THEORY**

**UNIT-I**: Basic principles of physics applied to soils, soil as a three phase system.

**UNIT-II**: Soil texture, textural classes, mechanical analysis, specific surface.

**UNIT-III:** Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Alleviation of soil physical constraints for crop production. Soil erosion and edibility

**UNIT-IV:** Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting-mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

**UNIT-V:** Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

**UNIT-VI:** Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

**UNIT-VII:** Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

**UNIT-VIII:** Composition of soil air; renewal of soil air-convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

**UNIT-IX:** Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

**PRACTICAL**

1. Determination of B.D, P.D and mass volume relationship of soil,
2. Mechanical analysis by hydrometer and international pipette method,
3. Measurement of Atterberg limits, Aggregate analysis - dry and wet,
4. Measurement of soil-water content by different methods,
5. Measurement of soil-water potential by using tensiometer and gypsum Blocks,
6. Determination of soil-moisture characteristics curve and computation of pore size, distribution,
7. Determination of hydraulic conductivity under saturated and unsaturated conditions,
8. Determination of infiltration rate of soil,
9. Determination of aeration porosity and oxygen diffusion rate,
10. Soil temperature measurements by different methods,
11. Estimation of water balance components in bare and cropped fields.

**TEACHING METHODS/ACTIVITIES**

Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Baver LD, Gardner WH and Gardner WR. 1972. Soil Physics. John Wiley & Sons.
2. Ghildyal BP and Tripathi RP. 2001. Soil Physics. New Age International.
3. Hanks JR and Ashcroft GL. 1980. Applied Soil Physics. Springer Verlag.
4. Hillel D. 1972. Optimizing the Soil Physical Environment toward Greater Crop Yields. Academic Press.
5. Hillel D. 1980. Applications of Soil Physics. Academic Press.
6. Hillel D. 1980. Fundamentals of Soil Physics. Academic Press.
7. Hillel D. 1998. Environmental Soil Physics. Academic Press.
8. Hillel D. 2003. Introduction to Environmental Soil Physics. Academic Press.
9. Indian Society of Soil Science. 2002. Fundamentals of Soil Science. ISSS, New Delhi.
10. Kirkham D and Powers WL. 1972. Advanced Soil Physics. Wiley-Inter science.
11. Kohnke H. 1968. Soil Physics. McGraw Hill.
12. Lal R and Shukla MK. 2004. Principles of Soil Physics. Marcel Dekker.
13. Oswal MC. 1994. Soil Physics. Oxford & IBH.
14. Arun Kumar Saha and Anuradha Saha. 2012. Text Book of Soil Physics. Kalyani Publisher.

## SOIL 523 SOIL BIOLOGY AND BIOCHEMISTRY 3 (2+1)

**OBJECTIVE**

To teach students the basics of soil biology and biochemistry, including Bio-geochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

**COURSE OUTCOME:** After completition of course student will have experience on the knowledge of soil microbes and their utility in research for solving field problem.

**THEORY**

**UNIT-I:** Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

**UNIT-II:** Microbiology and biochemistry of root- soil interface; phyllo-sphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora; Root rhizo- sphere and PGPR.

**UNIT-III:** Microbial transformations of nitrogen, phosphorus, sulphur, iron, Zinc and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, microbiology and biochemistry of decomposition of carbonaceous and protenaceous materials, cycles of important organic nutrients.

**UNIT-IV**: organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

**UNIT-V:** Preparation and preservation off Farmyard manure, animal manures, rural and urban composts and vermin-compost.

**UNIT-VI:** Biofertilizers– definition, classification, specifications, method of production and role in crop production; FCO specifications and quality control of biofertilizers.

**UNIT-VII:** Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms in pedogenesis –important mechanisms and controlling factors; soil genomics and bio-prospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil.

**PRACTICAL**

1. Determination of soil microbial population
2. Soil microbial biomass carbon
3. Elemental composition, fractionation of organic matter and functional groups
4. Decomposition of organic matter in soil
5. Soil enzymes

6. Measurement of important soil microbial processes such as ammonification, nitrification, $N_2$ fixation, S oxidation, P solubilisation and mineralization of other micro nutrients.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**READING MATERIALS**

1. Paul E.A. and Clark F.E. Soil Microbiology and Biochemistr.
2. Lynch J.M. Soil Biotechnology.
3. Willey J.M. Linda M. Sherwood and Woolverton C.J. Prescott's Microbiology.
4. Subba Rao N S. Advances in Agricultural Microbiology.
5. Alexander M. Introduction to soil Microbiology.
6. Chhonkar, P.K., Bhadraray, S., Patra, A.K. and Purakayastha, T.J. 2007. Experiments in Soil Biology and Biochemistry, Westville Publishing House, New Delhi.
7. Subba Rao, N.S. 1999. Soil Microbiology. Oxford & IBH, New Delhi.

## SOIL 524 SOIL EROSION AND CONSERVATION 3(2+1)

**OBJECTIVE**

To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

**COURSE OUTCOME**

After completition of course student will have experience on the knowledge of soil conservation and their utility in research for solving field problem.

**THEORY**

**UNIT-I:** History, distribution, identification and description of soil erosion problems in India.

**UNIT-II:** Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity- estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

**UNIT-III**: Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

**UNIT-IV:** Principles of erosion control; erosion control measures– agronomical and engineering; erosion control structures - their design and layout.

**UNIT-V:** Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

**UNIT-VI:** Watershed management- concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds, sediment measurement.

**PRACTICAL**

1. Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index.
2. Computation of kinetic energy of falling rain drops.
3. Computation of rainfall erosivity index (EI30) using rain gauge data.
4. Land capability classification of a watershed.
5. Visits to a watersheds.

**TEACHING METHODS/ACTIVITIES**

Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Biswas TD & Narayanasamy G. (Eds.) 1996. Soil Management in Relation to Land Degradation and Environment. Bull. Indian Society of Soil Science No. 17.

2. Doran JW and Jones AJ. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.
3. Gurmal Singh, Venkataramanan C, Sastry G and Joshi BP. 1990. Manual of Soil and Water Conservation Practices. Oxford & IBH.
4. Hudson N. 1995. Soil Conservation. Iowa State Univ. Press.
5. Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
6. Oswal MC. 1994. Soil Physics. Oxford & IBH.

## SOIL 525 SOIL SURVEY AND LAND USE PLANNING 2(1+1)

**OBJECTIVE**

To teach the better utilization of land for agricultural purposes, and better management of run off or surplus/ excessive rain-water in the catchment area for agricultural purposes in a watershed.

**COURSE OUTCOME:** After completion of course student will have knowledge of planning for land use in proper way for higher crop productivity.

**THEORY**

**UNIT-I:** Soil survey and its types; soil survey techniques- conventional and modern; soil series–

Characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; thematic soil maps, cartography, mapping units, techniques for generation of soil maps, application of remote sensing and GIS in soil survey and mapping of major soil groups of India

**UNIT-II:** Landform–soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT)– concept and application; approaches for managing soils and landscapes in the frame work of agro- ecosystem.

**UNIT-III:** Concept and techniques of land use planning; factors governing present land use; Land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application.

**UNIT-IV:** Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production. Status of LUP in India.

**PRACTICAL**

1. Aerial photo and satellite data interpretation for soil and land use.
2. Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales.
3. Land use planning exercises using conventional and RS tools.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, field visit and exposure visit

**SUGGESTED READINGS**

1. Boul SW, Hole ED, MacCraken RJ and Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ.
2. Brewer R. 1976. Fabric and Mineral Analysis of Soils. John Wiley & Sons.

## SOIL 531 REMOTE SENSING AND GIS TECHNIQUE FOR SOIL, WATER AND CROP STUDIES 3 (2+1)

**OBJECTIVE**

To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries, and their interpretation; application of remote sensing in general and with special reference to soil, plants and yield forecasting; to impart knowledge about geo-statistical techniques with special reference to krigging, and GIS and applications in agriculture.

**COURSE OUTCOME**: After completion of course student will have experience on the knowledge of remote sensing and their utility in research for solving field problem.

**THEORY**

**UNIT-I:** Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter, basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS)

**UNIT-II:** Sensor systems- camera, microwave radio meters and scanners; fundamentals of aerial photographs and multi-spectral imaging, hyper spectral imaging, thermal imaging; image processing and interpretations.

**UNIT-III:** Application of remote sensing techniques-land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, wasteland identification and management.

**UNIT-IV:** Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

**UNIT-V:** Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).

**PRACTICAL**

1. Familiarization with different remote sensing equipments and data products, Interpretation of aerial photographs and satellite data form aping of land resources,
2. Analysis of variability of different soil properties with classical and geo-statistical techniques,
3. Creation of data files in a data base programme,
4. Use of GIS for soils partial simulation and analysis,
5. To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning.

**TEACHING METHODS/ACTIVITIES**

Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**


1. Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
2. Elangovan K. 2006. GIS Fundamentals, Applications and Implementations. New India Publ. Agency.
3. Lillesand TM and Kiefer RW. 1994. Remote Sensing and Image Interpretation. 3rd Ed. Wiley.
4. Nielsen DR and Wendroth O. 2003. Spatial and Temporal Statistics. Catena Verloggmbh.
5. Star J and Esles J. 1990. Geographic Information System: An Introduction. Prentice Hall.
6. Indian Society of Soil Science 2015. Soil Science: An Introduction. ISSS, New Delhi


## SOIL 532 SOIL, WATER AND AIR POLLUTION 3 (2+1)

**OBJECTIVE**

To make the students aware of the problems of soil, water and air pollution associated with use of soils for crop production.

**COURSE OUTCOME:** After completition of course student will have knowledge on management of soil and water pollution.

**THEORY**

**UNIT-I:** Soil, water and air pollution problems associated with agriculture, nature and extent.

**UNIT-II:** Nature and sources of pollutants– agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants their CPC standards and effect on plants, animals and human beings.

**UNIT-III:** Sewage and industrial effluents– their composition and effect on soil properties/ health, and plant growth and human beings; soil as sink for waste disposal.

**UNIT-IV:** Pesticides– their classification, behaviour in soil and effect on soil microorganisms.

**UNIT-V:** Toxic elements– their sources, behaviour in soils, effect on nutrients availability, effect on plant and human health.

**UNIT-VI:** Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases– carbon dioxide, methane and nitrous oxide.

**UNIT-VII:** Risk assessment of polluted soil, Remediation/amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

**PRACTICAL**

1. Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing,
2. Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammonical nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants,
3. Management of contaminants in soil and plants to safeguard food safety, Air sampling and determination of particulate matter and oxides of sulphur, NO2 and O2 conc.
4. Visit to various industrial sites to study the impact of pollutants on soil and plants.

**TEACHING METHODS/ACTIVITIES**

Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**


1. Lal R, Kimble J, Levine E and Stewart BA. 1995. Soil Management and Greenhouse Effect. CRC Press.
2. Middlebrooks EJ. 1979. Industrial Pollution Control. Vol. I. Agro-Industries. John Wiley Inter science.
3. Ross SM. Toxic Metals in Soil Plant Systems. John Wiley & Sons.
4. Vesilund PA and Pierce 1983. Environmental Pollution and Control. Ann Arbor Science Publ.
5. B L Chaudhary and Jitendra Pandey. 2011. Environmental Studies. Apex Publishing House.
6. K K Singh, Asha Juwarkar, A K Singh and Alka Tomar. 2007. Air, Water and Soil Pollution. Kalyani Publishers.


## SOIL 533 LAND DEGRADATION AND RESTORATION 1 (1+0)

**OBJECTIVE**

To impart knowledge related to various factors and processes of land degradation and their restoration techniques.

**COURSE OUTCOME:** After completition of course student will have experience on restoration of degraded soil for optimization of crop yield.

**THEORY**

**UNIT-I:** Type, factors and processes of soil/land degradation and its impact on soil productivity including soil fauna, bio-degradation and environment.

**UNIT-II:** Land restoration and conservation techniques- erosion control, reclamation of salt affected soils; mine land reclamation, afforestation, organic products.

**UNIT-III:** Extent, diagnosis and mapping of land degradation by conventional and modern RSGIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing and degradation; global issues for twenty first century.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**


1. Biswas TD and Narayanasamy G. (Eds.). 1996. Soil Management in Relation to Land Degradation and Environment. Bull. Indian Soc. Soil Sci. 17, New Delhi.
2. Doran JW and Jones AJ. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Madison.
3. Greenland DJ and Szabolcs I. 1994. Soil Resilience and Sustainable Land Use. CABI.
4. Lal R, Blum WEH, Vailentine C and Stewart BA. 1997. Methods for Assessment of Soil Degradation. CRC Press.
5. Sehgal J and Abrol IP. 1994. Soil Degradation in India - Status and Impact. Oxford & IBH.

## SOIL 534 MANAGEMENT OF PROBLEM SOILS AND WATER 3 (2+1)

**OBJECTIVE**

To educate students about basic concepts of problem soils and brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.

**COURSE OUTCOME:** After completition of course student will have experience on solving field problem of problem soil and waters.

**THEORY**

**UNIT-I:** Area and distribution of problem soils– acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.

**UNIT-II:** Morphological features of saline, sodic and saline-sodic soils; characterization of salt affected soils-soluble salts, ESP, pH; physical, chemical and microbiological properties.

**UNIT-III:** Management of salt-affected soils; salt tolerance of crops mechanism and ratings; salt stress meaning and its effect on crop growth, monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils.

**UNIT-IV:** Acid soils-nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management.

**UNIT-V:** Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

**UNIT-VI:** Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

**PRACTICAL**

Characterization of acid, acid-sulfate, salt-affected and calcareous soils, Determination of cations ($Na^+$, $K^+$, $Ca^{++}$ and $Mg^{++}$) in ground water and soil samples,

Determination of anions ($Cl^-$, $SO_4^{--}$, $CO_3^{--}$ and $HCO_3^-$) in ground water and soil samples, Lime and gypsum requirements of acid and sodic soils.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Bear FE. 1964. Chemistry of the Soil. Oxford & IBH.
2. Jurinak JJ. 1978. Salt-affected Soils. Department of Soil Science & Biometeorology. Utah State Univ.
3. USDA Handbook No. 60. 1954. Diagnosis and improvement of Saline and Alkali Soils. Oxford & IBH.

## SOIL 535 INTRODUCTION TO NANOTECHNOLOGY 3 (2+1)

**OBJECTIVE**

To impart basic knowledge about nano-science, properties of nanoparticles and their applications in biology

**COURSE OUTCOME:** After completition of course student will have experience on the knowledge of nano science and their utility in research for solving field problem.

**THEORY**

**UNIT-I:** General introduction: Basics of quantum mechanics, harmonic oscillator, magnetic phenomena, band structure in solids, Mössbauer effect and spectroscopy, optical phenomena, bond in solids, anisotropy.

**UNIT-II:** Nanostructures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nano-tube sand nano-wires, fullerenes (buckballs, graphene). Nano-fabrication and nano patterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, process of synthesis of nano powders, electro deposition, and important nano materials.

**UNIT-III:** Mechanical properties, magnetic properties, electrical properties, electronic conduction with nano-particles, investigating and manipulating materials in the nano scale: Electron microscopy.

**UNIT-IV:** Nano-biology: Interaction between biomolecules and nano-particle surface, different types of inorganic materials used for the synthesis of hybrid nano bio-assemblies, application of nano in agriculture, current status of nano-biotechnology, future perspectives of nano-biology, nano-sensors.

**PRACTICAL**

1. Sources of nanoparticles and its preparation by different approaches.
2. Electro spinning and its use in agriculture and allied sector.
3. Equipments used in Nanotechnology: its principle and uses.
4. Acquaintances with different equipments used in nanotechnology.
5. Synthesis and characterization of Ag and ZnO nanoparticles.
6. Mode of action of ZnO nanoparticles against soil borne diseases.
7. Study on efficacy of ZnO nanoparticles as seed treating agent on plant growth parameters.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Baland A.A. and Wang K.L.2006. Hand book of semiconductor nano-structures and nano-devices, American Scientific Publishers,
2. Gregory Timp. 1999. Nano-technology, Springer Verlag.
3. Challa Kumar. 2006. Nano-technologies for the life sciences, Wiley-VCHGmbH.
4. Michael Kohlerand Wolfgang Frintzsche.2007. Nano-technology: Introduction to nano-structuring techniques, Wiley-VCH VerlagGmbH.
5. Margaret E. Kosal–Dordrecht. 2009. Nano-technology for chemical and biological defense, Springer, 2009.

## SOIL 536 RADIOISOTOPES IN SOIL AND PLANT STUDIES 2 (1+1)

### OBJECTIVE

To train students in the use of radio isotopes in soil and plant research.

**COURSE OUTCOME:** After completition of course student will have experience on the knowledge of radio activity and their utility in research for solving field problems.

### THEORY

**UNIT-I:** Atomic structure, radioactivity and units; radioisotopes-properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter, artificial radioactivity.

**UNIT-II:** Principles and use of radiation monitoring instruments-proportional, Geiger Muller counter, solid and liquid scintillation counters; neutron moisture meter, mass spectrometry, autoradiography.

**UNIT-III:** Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating.

**UNIT-IV:** Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes.

**PRACTICAL**

1. Storage and handling of radioactive materials.
2. Determination of half-life and decay constant.
3. Preparation of soil and plant samples for radioactive measurements.

4. Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radioisotopes.
5. Determination of A, E and L values of soil using 32P/65Zn
6. Use of neutron probe for moisture determination.
7. Sample preparation and measurement of 15N enrichment by mass.
8. Spectro-photometery/emission spectrometry.

**TEACHING METHODS/ACTIVITIES:** Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Comer CL. 1955. Radioisotopes in Biology and Agriculture: Principles and Practice. Tata McGraw Hill.
2. Glasstone S. 1967. Source Book on Atomic Energy. East West Press.
3. Michael FL and Annunziata. 2003. Handbook of Radioactivity Analysis. Academic Press.
4. Bhupinder Singh. 2021. Radioisotopes in Soil and Plant Studies. Indian Council of Agricultural Research.

# DEPARTMENT OF AGRICULTURAL ECONOMICS
# AGRICULTURE UNIVERSITY JODHPUR

**Semester wise Course Title and Credits: for M.Sc. (Agri.) Agricultural Economics:**

| S.No. | Course Code adapted | Course Title | Credit hrs. |
|---|---|---|---|
| **Semester -I** | | | |
| 1. | AECON-511* | Micro Economic Theory and Applications | 3(3+0) |
| 2. | AECON-512* | Macro Economics and Policy | 2(2+0) |
| 3. | AECON-513* | Agricultural Production Economics | 2(1+1) |
| 4. | AECON-514 | Research Methodology for Social Sciences | 2(1+1) |
| 5. | AECON-515 | Indian Economy: History and Contemporary Issues | 2(2+0) |
| 6. | AECON-516 | Natural Resource and Environmental Economics | 2(1+1) |
| 7. | AECON-517 | Evolution of Economic Thought | 1(1+0) |
| **Semester -II** | | | |
| 1. | AECON-521* | Agricultural Marketing and Price Analysis | 3(2+1) |
| 2. | AECON-522 | Econometrics | 3(2+1) |
| 3. | AECON-523 | Agricultural Development and Policy Analysis | 2(2+0) |
| 4. | AECON-524 | International Economics | 2(1+1) |
| 5. | AECON-525 | Institutional Economics | 1(1+0) |
| 6. | AECON-526 | Development Economics | 2(2+0) |
| **Semester -III** | | | |
| 1. | AECON-531 | Agricultural Finance and Project Management | 3(2+1) |
| 2. | AECON-532* | Linear Programming | 2(1+1) |
| 3. | AECON-533 | Commodity Future Trading | 2(2+0) |
| 4. | AECON-534 | Rural Marketing | 2(2+0) |
| **Semester -IV** | | | |
| 1. | AECON-541 | Master Seminar | 1(1+0) |
| 2. | AECON-542 | Comprehensive | NC |
| 3. | AECON-543 | Research | 30 |
| Minor Course | | | 08 |
| Supporting Course | | | 06 |
| Common Compulsory Course | | | 05 |

* Core Courses suggested by course committee meeting and the above courses shall be offered as per schedule of the concerned departments.

## COURSE CONTENTS:

### AECON 511 MICRO ECONOMIC THEORY AND APPLICATIONS 3 (3+0)

**WHY THIS COURSE:** Markets form an integral part of the economy. They are governed by demand and supply mechanism with profit making its ultimate goal. Thus, it is imperative to expose the students towards how the markets function, their types and how the buyers and sellers behave. That will help them make correct decision when it comes to price setting and choice of product.

**OBJECTIVE:** The course envisages the concepts and principles embodying micro-economics. The economic problems, functioning of price mechanism, theory of household behaviour and consumer's demand function. Theory of firm, supply determinants, determination of price under different market structures and factor pricing (micro economic components).

**COURSE OUTCOME:** After completion of the course the student will be able to

1. Get acquainted with the basic concepts of market functions.
2. Build up vision towards how consumers makes choices and market reaches the equilibrium.
3. Develop decision making skill for firms about product selections and scale of production to ensure maximum profit.
4. Understand about different types of markets existing in the real world, their principles and whereabouts.

**Organization of the course-** The course is organized as follows:

**THEORY**

**Block 1- Introduction to micro-economics**

**UNIT-I**: Basic Concepts: A review Scarcity and Choice; Production possibility frontier, Positive and normative economics; concepts of opportunity cost, Demand and Supply: determinants of individual demand/supply; demand/supply schedule and demand/supply curve; market versus individual demand/supply; shifts in the demand/supply curve.

**Block 2- Insight of consumer, production and cost involved**

**UNIT-I:** Consumer Choice Cardinal Utility Approach - Ordinal Utility Approach -Budget sets and Preferences under different situations– Hicks and Slutsky income and substitution effects– Applications of Indifference curve approach- Revealed Preference Hypothesis– Consumer surplus - Derivation of Demand curve –Elasticity of demand- Demand and supply together; how prices allocate resources; controls on prices- price floor and price ceiling – applications in agriculture

**UNIT-II:** Production and Cost, Production functions: single variable - average and marginal product, variable proportions, stages of production. Two variables - isoquants, returns to scale and to a factor; factor prices; Technical progress; cost minimization and output maximization; Elasticity of substitution. Expansion path and the cost function.

Concept of economic cost; Short run and long run cost curves; increasing and decreasing cost industries; envelope curve; L-shaped cost curves; economies of scale; revenue and expenditure, elasticity and marginal revenue; Firm equilibrium and profit.

**Block 3- Overview of market**

**UNIT-I:** Market Forms, Behaviour of profit maximizing firms and the production process- Perfect competition: Equilibrium of the market. Long run industry supply, applications: effects of taxes and subsidies; Monopoly: Equilibrium; supply; multiplant firm; monopoly power; deadweight loss; price discrimination; Monopolistic Competition: Product differentiation; equilibrium of the firm in the industry-with entry of new firms and with price competition. Comparison with pure competition. Duoploy: Cournot model and reaction curves; Stackelberg‘s model, Bertrand model; Oligopoly.

**UNIT-II:** Factor Markets, Labour and land markets - basic concepts (derived demand, productivity of an input, marginal productivity of labour, marginal revenue product); demand for labour; input demand curves; shifts in input demand curves; competitive labour markets; Economic rent and quasi rent .

**TEACHING METHODS/ ACTIVITIES**

- Lectures
- Case studies
- Assignments (Group/individual)
- Group Discussions on practises done by firms.
- Power point presentations by students.
- Exploring the agricultural market and identification of industries and their type.

**SUGGESTED READINGS:**

1. Modern Micro Economics by A. Koutsoyiannis, Published by MACMILLAN PRESS LTD
2. Micro Economic Theory by Ferguson and Gould by Richard D Erwin INC USA
3. Richard A. Bilas, Micro Economic Theory.
4. Leftwich Richard H., The Price System and Resources Allocation
5. Allen, C.L., A Frame Work of Price Theory.

| AECON 512 | MACRO ECONOMICS AND POLICY | 2 (2+0) |
|---|---|---|

**WHY THIS COURSE:** The economy of the nation is governed by certain rules, regulation and principles. The students has to gain knowledge of the mechanism through which the large economies are controlled and ensure that welfare prevails. They are entitled to know the transactions between different markets and policies framed to keep value of money under control.

**OBJECTIVE:** The course envisages the concepts and principles of macroeconomics from classical to Keynesian theories. The other component deals with the monetary system-money, credit and banking system, value of money and economic activities, national income accounting and approaches to estimate national income theory of income and employment determination and inflation.

**COURSE OUTCOME:** After the completion of the course the student will be able to-

1. Understand the concepts of national income, theories build up to understand macroeconomics.
2. Understand better about the policies and government steps taken to control the economic transaction of the nation.
3. Workout how the investment acts as a catalyst in national development.

**ORGANIZATION OF THE COURSE-** The course is organised as follows:

**THEORY**

**Block 1- Conceptualizing Macro Economics**

**UNIT-I: Introduction: Measurement and Concepts;** Basic concepts and scope of Macro-economics, National Income Accounting: Methods of measurement of key macro-economic aggregates, relationship of national income and other aggregates (with numerical exercises), real and nominal income.

**Block 2- Theories of macroeconomics**

**UNIT-I: Classical Macroeconomics;** Say's Law, Quantity Theory of Money, aggregate labour supply and demand of labour, Classical theory of determining output, wages and prices.

**UNIT-II: Income And Spending: Keynesian Framework;** Simple Keynesian model of income determination; Keynesian Multiplier- aggregate spending, taxation, transfer payments, foreign spending, balanced budget; budget surplus (with numerical exercises).

**Block 3- Money, Consumption and Inflation**

**UNIT-I: Money, Interest and Income;** Goods market equilibrium-IS curve; Demand for Money, the Liquidity Preference Theory -Liquidity Trap; asset market equilibrium- LM curve; simultaneous equilibrium in goods and asset market- effect of fiscal and monetary policy.

**UNIT-II: Theories of Aggregarte Consumption and Investment;** Absolute Income Hypothesis, Relative Income Hypothesis, Fisher's Inter-temporal Choice Model, Life-Cycle and Permanent Income Hypotheses; Profits and Accelerator Theory.

**UNIT-III: Inflation and Unemployment;** Inflation: Nature, Effects and control; Types of inflation – demand pull, cost push- stagflation, core inflation, hyperinflation; Phillips curve.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Case studies.
- Assignments (Group/individual).
- Group Discussions on inflation.

**SUGGESTED READINGS**

1. Stonier & Hegue, A Text Book of Economic Theory
2. Samuelson, P. A.1948. Foundation of Economic Analysis. Harvard University Press
3. M. C. Vaish, Allid, New Delhi, 1983. Macro–Economics Theory.
4. Gardner Ackley, Macmillan, New York, 1961 Macro–Economics Theory:
5. T. F. Dernburg & D. M. Mcdougali-Macro Economics
6. G. Sirkin – Introduction to Macro–Economics Theory
7. R.L. Heibroker-Understanding Macro–Economics
8. J.K Mehta –Macro Economics
9. Michael R. Edgemand – Macro-Economics: Theory & Policy
10. David' W. Pearce –The dictionary of modern Economics.

| AECON 513 | AGRICULTURAL PRODUCTION ECONOMICS | 2 (1+1) |
|---|---|---|

**WHY THIS COURSE:** Production in agriculture is the outcome of the input factors involved. In this competitive and uncertain market, it is important that the farmers take the right decision about the combination of inputs that will result in higher income. Thus, as an economist it is a pre-requisite that the students understand the interaction between output and input. And work out the most effective production plan.

**OBJECTIVES:** To expose the students to develop the concept, significance and uses of production economics. To understand the relationships between factors and output. To learn how to decide the combination of inputs to be used as per the resources available. Ensure that the production process works efficiently.

**COURSE OUTCOME:** After the successful completion of the course the student will be able to-

- Understand how the factors and output interact with each other.
- Work out whether the production system is working efficiently and point out the loop holes.
- Apply the knowledge of costs and profits to work out the demand and supply functions.
- This will result into more efficient decision making.

**Organization of the course-** The course is organised as follows:

**THEORY**

**Block 1- Introduction to Production Economics**

**UNIT-I**: Concepts of production economics, Nature, scope and significance of agricultural production economics- Agricultural Production processes, character and dimensions-spatial, temporal - Centrality of production functions, assumptions of production functions, commonly used forms- Properties, limitations, specification, estimation and interpretation of commonly used production functions.

**Block 2- Factors and costs**

**UNIT-I:** Factors and theory of production, Factors of production, classification, interdependence, and factor substitution Determination of optimal levels of production and factor application - Optimal factor combination and least cost combination of production - Theory of product choice; selection of optimal product combination.

**UNIT-II: Concepts of cost;** Cost functions and cost curves, components, and cost minimization - Duality theory – cost and production functions and its applications -Derivation of firm's input demand and output supply functions -Economies and diseconomies of scale.

**Block 3- Assessment**

**UNIT-I:** Dynamics of economic assessment, Technology in agricultural production, nature and effects and measurement - Measuring efficiency in agricultural production; technical, allocative and economic efficiencies - Yield gap analysis concepts- types and measurement - Nature and sources of risk, modeling and coping strategies.

**PRACTICAL**

Different forms of production functions -specification, estimation and interpretation of production functions – returns to scale, factor shares, elasticity of production - physical optima-economic optima-least cost combination- optimal product choice- cost function estimation, interpretation estimation of yield gap - incorporation of technology in production functions- measuring returns to scale-risk analysis.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Assignments (Group/individual).
- Group Discussions on working out.
- Power point presentations by students.
- Exploring the agricultural market and identification of industries and their type.

**SUGGESTED READINGS**


1. E. O. Heady, Economics of Agricultural Production and resources use.
2. John P. Doll and Frank Orazem, Production Economics: Theory with application
3. Heady E.O. & Dillon, J L. 1961. Agricultural Production functions. Kalyani Publishers, Ludhiana, India. 667 p.
4. 3. Baumol, W.G. 1973. Economic theory and operations analysis. Practice Hall of India Private Limited, New Dehli.626 p.
5. 4. Gardner BL & Rausser GC. 2001. Handbook of Agricultural Economics Vol. I Agricultural Production. Elsevier.

## AECON 514 RESEARCH METHODOLOGY FOR SOCIAL SCIENCES 2 (1+1)

**WHY THIS COURSE:** Planning of research is very crucial to conduct a successful research. There is need to give an insight to the student about how to conduct a research, right from data collection to analysis and finally writing the references.

**OBJECTIVE:** The course deals with scientific methods of research, the initiation of an inquiry, formulation of research problems and hypotheses, the role of induction and deduction in research, collection and analysis of date and interpretation of results

**COURSE OUTCOMES**

After the successful completion of this course, student will be able to-

1. Understand fundamentals of research.
2. How to carefully plan out the research work and conduct it.

**Organization of the course-** The course is organised as follows:

**THEORY**

**Block 1- Concepts of research methodology**

**UNIT-I:** Concepts of research methodology, Importance and scope of research in agricultural economics. Types of research - Fundamental vs. Applied. Concept of researchable problem – research prioritization – selection of research problem. Approach to research – research process.

**Block 2- Building up hypothesis and sample selection**

**UNIT-I:** Hypothesis: Framing and Testing, Hypothesis – meaning - characteristics - types of hypothesis- review of literature- setting of Course Objective and hypotheses- testing of hypothesis.

**UNIT-II:** Sampling, Sampling theory and sampling design– sampling error- methods of sampling– probability and non-probability sampling methods- criteria to choose. Project proposals– contents and scope- different types of projects to meet different needs– trade-off between scope and cost of the study. Research design and techniques– Types of research design.

**Block 3- Data Collection and Analysis**

**UNIT-I:** Data Collection, Data collection – assessment of data needs – sources of data collection – discussion of different situations. Mailed questionnaire and interview schedule – structured, unstructured, open ended and closed-ended questions. Scaling Techniques. Preparation of schedule – problems in measurement of variables in agriculture. Interviewing techniques and field problems - methods of conducting survey – Reconnaissance survey and Pre testing.

**UNIT-II:** Data Analysis, Data coding, tabulation, cleaning. –Multivariate analysis –factor analysis' PCA' cluster analysis. Universal procedures for preparation of bibliography – writing of research articles.

**PRACTICAL**

Exercises in problem identification. Project proposals – contents and scope. Formulation of Objective and hypotheses. Assessment of data needs – sources of data – methods of collection of data. Methods of sampling – criteria to choose – discussion on sampling under different situations. Scaling Techniques – measurement of scales. Preparation of interview schedule - Field testing. Method of conducting survey. Exercise on coding, editing, tabulation and validation of data. Preparing for data entry into computer. Hypothesis testing – Parametric and Non-Parametric Tests. Exercises on format for Thesis / Report writing. Presentation of the results.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Case studies.
- Assignments (Group/individual).
- Group Discussions

**SUGGESTED READINGS**

1. Research Methodology in Agricultural Economics, Baker, C. B. ii. An Introduction to Logic and Scientific Method, Cohen, M.R. and Nagel, R.
2. The Theory of Enquiry, Devey, J. Logic
3. Social Science Research and Thesis Writing, Dhondhyal, S. P.
4. Correlation Analysis, Ezekiel, M.

5. Linear Programming Methods, Heady, E. O.
6. An Introduction to Scientific Research, Willson, E. R.
7. Research Methodology: A Survey, Anil Kumar Alts, New Delhi, 2008.

## AECON 515 INDIAN ECONOMY: HISTORY AND CONTEMPORARY ISSUES 2 (2+0)

**WHY THIS COURSE:** India is a developing economy. The evolution of the Indian economy will enlighten the student with how an economy develops. Students will understand how the policies and measures taken shape up the economy of the country.

**OBJECTIVE:** To introduce the students to the economic history over a period of time. It also highlights the contemporary issues of Indian economy.

**COURSE OUTCOME:**

1. After the completion of the course the student will be able to-
2. Visualize how the Indian economy has evolved.
3. Get acquainted with the basic steps involved in the working of the national economy.

**ORGANIZATION OF THE COURSE-** The course is organised as follows-

**THEORY**

**Block 1- History of Indian Economy**

**UNIT-I: India From Independence to Liberalization**, An overview of the economic developments during the period 1947-1980; Objectives and strategies of planned economic development and the role of the State; Sectoral growth performance; savings and investment; Demographic trends and issues; education; health and malnutrition; Trends and policies in poverty; inequality and unemployment.

**UNIT-II:** India since 1980's (Liberalization and beyond): overview, Policy Changes since 1980s.The 1990 Crisis. Causes and Effects of liberalization. Regional differences: infrastructure, primary, secondary and tertiary sector.

**UNIT-III:** MACRO TRENDS SINCE 1990, Growth; Savings and Investment, Employment; productivity; diversification; Agro-based industries; competition policy; foreign investment, Regional differences.

**Block 2- Contemporary Issues**

**UNIT-I:** CONTEMPORARY ISSUES, Monetary and Financial trends- areas of government spending in India, Capital expenditure, revenue expenditure, plan expenditure, non-plan expenditure, Deficits (fiscal, primary, revenue), impact of fiscal deficit on economy, Capital receipts, revenue receipts, tax and non-tax revenue, direct and indirect taxes, need to rationalize tax structure. Goods and Services Tax (GST). Union Budget, Zero-base budgeting, Gender budgeting, Fiscal devolution and centre-state financial relations in India, WPI, CPI implicit deflators. Foreign Trade policy.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Power point presentation by students on monetary and fiscal policy in past and present.
- Assignments (Group/individual).
- Group Discussions on Tax and its reforms.

**SUGGESTED READING**

1. Indian Economy By Dutt and Sundaram.

## AECON 516 NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS 2 (1+1)

**WHY THIS COURSE:** Sustainable development is the need of the hour. The economic activities affect not only the society but also the environment. Every activity has its social cost. The students, hence will be taught about the economic aspect of environment.

**OBJECTIVE:** To understand about economics of environment and social costs incurred due to economic development. Work out methods to maintain environment quality and reduce social costs Learning outcomes: After successful completion of this course, the student will be able to-

Work out the plan for extraction / use of natural resource in most economical way. Understand the environment and its pollution. Learn how markets are affected if environment is not taken into consideration. Gain proficiency in rules and regulation governing economic aspect of environment.

**ORGANIZATION OF THE COURSE:** The course is organised as follows-

**THEORY**

**Block 1- Introduction to natural resource and environmental economics**

**UNIT-I:** Basic Foundation, Concepts, Classification and Problems of Natural Resource Economics – Economy Environment interaction – The Material Balance principle, Entropy law-Resources Scarcity -Limits to Growth - Measuring and mitigating natural resource scarcity – Malthusian and Recardian scarcity – scarcity indices - Resource Scarcity and Technical Change.

**Block 2- Insights of the subject**

**UNIT-I:** Theories and economics of natural resources, Theory of optimal extraction renewable resources –economic models of oil extraction- efficiency- time path of prices and extraction - Hotelling's rule, Solow-Harwick's Rule. Theory of optimal extraction exhaustible resources – economic models of forestry and fishery.

**UNIT-II:** Functioning of Market, Efficiency and markets – market failures - externalities – types - property rights – transaction costs – Coase's theorem and its critique - public goods - common property and open access resource management - Collective action.

**Block 3-** Dealing with the issues and sustainability

**UNIT-I:** Environmental Issues, Environmental perspectives - biocentrism, sustainability, anthropocentrism –Environmental problems and quality of environment - Sources and types of pollution -air, water, solid waste, land degradation – environmental and economic impacts - Economics of pollution control -efficient reduction in environmental pollution.

**UNIT-II:** Regulations, Environmental regulation – economic instruments - pollution charges - Pigovian tax – tradable permits – indirect instruments - environmental legislations in India.

**UNIT-III:** Sustainability aspects, Concept of sustainable development - Economic Perspective - Indicators of sustainability, Relation between development and environment stress-Environmental Kuznet's curve Environmental Accounting – resource accounting methods - International Environmental Issues– climate change – likely impacts mitigation efforts and international treaties.

**PRACTICAL**

Exhaustible resource management– optimum rate of oil extraction. Renewable resource management- optimum harvest of Forestry/fishery. Exercise on pollution abatement– I. Exercise on pollution abatement II. Concepts in valuing the environment. Taxonomy of valuation techniques. Productivity change method- substitute cost method- Hedonic price method- Travel cost method -Contingent valuation methods. Discount rate in natural resource management. Environment impact assessment Visit to Pollution Control Board.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Case studies.
- Assignments (Group/individual).

**SUGGESTED READINGS**

1. Economics of Natural Resource and Environment- David W. Pearce and R. Kerry Turner
2. Economism: Bad Economics and the Rise of Inequality by James Kwak
3. Environmental and Natural Resource Economics by Tom Tietenberg and Lynne Lewis
4. Energy Economics by Peter M. Schwarz.

## AECON 521 AGRICULTURAL MARKETING AND PRICE ANALYSIS 3 (2+1)

**WHY THIS COURSE:** The ultimate aim of production process is to sell the produce in the market and generate income. Markets serves as platform where this exchange takes place. Agriculture markets are different from other markets due to the nature of the commodity. Thus, it is important to develop a strong foundation of agricultural marketing, its components and issues. The student needs to know about the multi-pronged ways of marketing the produce, agencies involved. In this modern era, it is important to understand how technology is transforming this sector.

**OBJECTIVE:** The course is designed to acquaint the students about the basics of dynamics of agricultural marketing. The content includes supply, demand and marketing of farm production, marketing functions and channels, marketing costs, margins and efficiency, agricultural prices, New marketing formats like e-marketing, e-NAM future trading, supply chain management, market intelligence *etc*.

**COURSE OUTCOME:** After the completion of this course the student will be able to-
1. Understand the whereabouts of agricultural marketing.
2. The different forms of marketing existing in this sector.
3. Gain expertise in market intelligence and price forecasting.

**ORGANIZATION OF THE COURSE:** The course is organised as follows:

**THEORY**

**Block 1- Introduction to Agricultural Marketing**

**UNIT-I:** Introduction to agricultural marketing, New Concepts in Agricultural Marketing - Characteristic of Agricultural product and Production– Problems in Agricultural Marketing from Demand and Supply and Institutions sides. Market intermediaries and their role - Need for regulation in the present context - Marketable & Marketed surplus estimation. Marketing Efficiency - Structure Conduct and Performance analysis – Vertical and Horizontal integration - Integration over space, time and form-Vertical coordination.

**Block 2- Agricultural Markets**

**UNIT-I:** Aspects of agricultural marketing, Different Forms of marketing: Co-operatives Marketing– APMC Regulated Marketing– Direct marketing, Farmer Producer Companies, e-NAM and marketing under e-NAM, e-marketing Contract farming and Retailing, Organized retailing- Supply Chain Management- State trading, Warehousing and other Government agencies- Performance and Strategies- Market infrastructure needs, performance and Government role - Value Chain Finance.

**UNIT-II:** Future marketing and government, Introduction to Commodities markets and future trading- Basics of commodity futures- Operation Mechanism of Commodity markets– Price discovery- Hedging and Basis- Fundamental analysis- Technical Analysis- Role of Government/SEBI in promoting commodity trading and regulatory measures.

**Block 3- Advances in Agricultural Marketing**

**UNIT-I**: Use of Information Technology. Role of Information Technology and Market Intelligence in marketing of agricultural commodities, electronic auctions (e-bay), e-Chaupals, Agmarknet and Domestic and Export market Intelligence Cell (DEMIC).

**UNIT-II:** Dynamics of price, Price forecasting – time series analysis – time series models – spectral analysis. Price policy and economic development – non-price instruments.

**PRACTICAL**

Supply and demand elasticities in relation to problems in agricultural marketing. Price spread and marketing efficiency analysis. Marketing structure analysis through concentration ratios. Performance analysis of Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products. Supply Chain Analysis - quantitative estimation of supply chain efficiency - Market Intelligence – Characters, Accessibility, and Availability Price forecasting. Online searches for market information sources and interpretation of market intelligence reports– commodity outlook - Technical Analysis for important agricultural commodities - Fundamental Analysis for important agricultural commodities- Presentation of the survey results and wrap-up discussion.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Case studies.
- Assignments (Group/individual).
- Group Discussions on price volatility and control measures prevailing.
- Power point presentations by students on government schemes.

- Visit to eNAM mandies, Warehouses *etc.*

**SUGGESTED READINGS**

1. Acharya, S. S. & Agarawal, N.L.2004. Agricultural Marketing in India. Oxford and IBH Publishing company Pvt. Ltd. New Delhi.
2. Acharya, S. S. & Agarawal, N. L. 1994. Agricultural Prices-Analysis and Policy. Oxford and IBH Publishing company Pvt. Ltd. New Delhi.
3. Richard H Kohls and Joseph N. Uhl: Marketing of Agricultural products by Collier MacMillan International.

## AECON 522 ECONOMETRICS 3 (2+1)

**WHY THIS COURSE:** Development of analytical skills is imperative to make students proficient in conducting quality research work. The knowledge of variables, their models, and problems encountered when dealing with variables will build up a compatibility with the analytical aspects.

**OBJECTIVE:** The course provides knowledge of the econometric methods like time series analysis, linear regression models and their application in economic analysis. The course provides an insight into the econometric problems in analyzing time series and cross section data.

**COURSE OUTCOMES:** After the completion of the course, the student will be able to-

1. Understand the variables and the properties of regression models.
2. Identify the problems in variables and remove them before conducting the analysis and avoid biased results.

**ORGANIZATION OF THE COURSE:** The course is organised as follows-

**THEORY**

**Block 1- Introduction to Econometrics**

**UNIT-I:** Introduction Relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics-regression analysis.

**Block 2- Classical Regression**

**UNIT-I:** Classical Linear Regression, Basic two variable regression – assumptions estimation and interpretation approaches to estimation – OLS and their properties – extensions to multi-variable models-multiple regression estimation and interpretation.

**UNIT-II**: Breaking down of Classical assumptions, Violation of assumptions – identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches – model misspecification.

**Block 3- Qualitative Variables**

**UNIT-I**: Qualitative variables and simultaneous equation models, Use of dummy variables-Introduction to simultaneous equations- identification problem.

**PRACTICAL**

Single equation two variable model specification and estimation– hypothesis testing transformations of functional forms and OLS application-estimation of multiple regression model– hypothesis testing– testing and correcting specification errors– testing and managing Multicollinearity –estimation of regressions with dummy variables

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Assignments (Group/individual).

**SUGGESTED READINGS**

1. Dorfman R. 1996. Linear Programming and Economic Analysis. McGraw Hill.
2. Greene, W.H. 2002. Econometric Analysis. Pearson Education.
3. Johnston, J. and Dinardo, J. 2000. Econometric Methods. Mc Graw-Hill.
4. Koutseyianis, A. 1997. Theory of Econometrics. Barner & Noble.
5. Maddala, G.S. 2002. Econometrics. Mc Graw-Hill.
6. Pinndyck, R.S. and Rubinfeld, D.L. 1990. Econometric Models and Econometric Forecasts. Mc Graw Hill.

## AECON 523 AGRICULTURAL DEVELOPMENT AND POLICY ANALYSIS 2 (2+0)

**WHY THIS COURSE:** The ultimate aim of the economies is to attain a satisfactory level of development. Development ensures that there is not only increase in income but also the distribution is such that lesser inequalities exist. The students need to know what is development and its related concepts. All the policies framed are with one sole objective of increasing the welfare. Thus, once concept of development is build up, students can better understand policies and their genesis.

**OBJECTIVES:** Concept of economic development and policy, theories of development, performance of Indian agriculture. The process and implementation of policies over a period of time.

**COURSE OUTCOME:** After the completion of the course the student will be able to-

1. Understand the concept of development and its preference over growth.
2. Visualize how the agriculture sector is performing in this aspect.
3. Understand the motive behind the policies and their implementation.

**THEORY**

**Block 1- Introduction**

**UNIT-I:** Introduction, Role of agriculture in economic / rural development – Evolution of thinking on agriculture and development ; Agricultural development– meaning, stages and determinants - Population and food supply - need for sound agricultural policies.

**Block 2- Theoretical Concepts**

**UNIT-I:** Theories of Agricultural Development, Resource exploitation model- Conservation model- Location (Urban impact) model- Diffusion model- High pay-off input model-Induced Innovation Model- Agricultural R&D and Linkages.

**Block 3- Performance and policies**

**UNIT-I:** Performance of Indian Agriculture, Agrarian structure and land relations; trends in performance and productivity; agrarian structure and technology; credit, commerce and technology; capital formation; subsidies; pricing and procurement; Post Green Revolution agriculture; Production and productivity crisis in agriculture; Regional differences; Food Security, PDS system and Malnutrition.

**UNIT-II:** Agricultural Policy: Process and Implementation, Instruments of Agricultural Policy; Process of agricultural policy formulation, implementation, Monitoring and Evaluation in India; Global experiences in participatory approach to Agricultural policy process; critical review of various elements of Indian agricultural policy-resource policies– credit policies – input and product marketing policies – price policies; WTO – Agreement on Agriculture; Planning models. Planning for utilization of resources and Indian Five Year Plans.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Assignments (Group/individual).
- Group Discussions on evolution of Indian Agriculture and Development indices.
- Power point presentation by students on policies and their relevance.

**SUGGESTED READINGS**

1. Albert O. Hirschman 1958. Strategy of Economic Development. New Man Yale University
2. Simon Kuznets 1965. Economic Growth and Structures. Oxford New Delhi.
3. Das Gupta AK. 1965. Planning and Economic Growth. George Allen and Unwin London
4. Robert E. Baldwin 1966. Economic Development and Growth. John Willey, New York.

## AECON 524 INTERNATIONAL ECONOMICS 2 (1+1)

**WHY THIS COURSE:** The era of Globalisation, liberalization and privatization has unified the whole world. There is trade across national boundaries and one economy has effect on the other. Getting familiar with national economy is not sufficient to understand the mechanism of trade and economic aspects. Thus, this course is designed to teach student about the trade as international level.

**OBJECTIVES:** The major objective of this course is to give an insight of the interactions between national economies. What are the theories governing the trade across national boundaries. The methods involved to regulate the international trade and institutions involved.

**COURSE OUTCOME:** After successful completion of the course the student will be able to –

1. Understand how trade take place between nations.
2. Be able to work out strategies to maintain a favourable trade balance.
3. Understand how the institutions play role in regulating the cross country trade and deal with the issues.

**ORGANIZATION OF THE COURSE:** The course is organised as follows-

**THEORY**

**Block 1- Introduction**

**UNIT-I:** Concepts of International Economics, Scope and Significance of International Economics - The role of trade- General Equilibrium in a Closed Economy (Autarky Equilibrium) – Equilibrium in a Simple Open Economy – Possibility of World Trade - Trade gains and Trade Equilibrium.

**Block 2- Models, Rate and Terms of Trade**

**UNIT-I:** Barriers to trade, Tariff, Producer Subsidy, Export Subsidy, Import Quota and Export Voluntary Restraints- The Case of Small Country and Large Country Case.

**UNIT-II:** Models of trade, Ricardian Model of Trade- Specific Factors Model- Heckscher - Ohlin Model- Trade Creation and Trade Diversion – Offer Curve - Export Supply Elasticity and Import Demand Elasticity –Comparative Advantage and Absolute Advantage.

**UNIT-III:** Rates and Terms of trade, Official Exchange Rate and Shadow Exchange Rate - Walra's Law and Terms of Trade – Trade Blocks.

**Block 3- Institutions**

**UNIT-I:** Trades Institutions, IMF, World Bank, IDA, IFC, ADB – International Trade agreements – Uruguay Round – GATT – WTO.

**PRACTICAL**

Producer's Surplus, Consumer's Surplus, National Welfare under Autarky and Free Trade, Equilibrium with small and large country assumption- Estimation of Trade Gains- Estimation of competitive and comparative measures like NPC, EPC, ERP and DRC- Estimation of Offer Curve Elasticity- Estimation of Effect of Tariff, Export Subsidy, Producer Subsidy, Import Quota and Export Voluntary Restraints on National Welfare- Estimation of Ricardian Model -Estimation of Effect of Trade under Specific Factor Model- Estimation of trade Equilibrium under Heckscher - Ohlin model - Trade Creation and Diversion.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Case studies.
- Assignments (Group/individual).
- Power point presentation on International Trade in current scenario.

**SUGGESTED READINGS**

1. International Economics by Kindelberger Published by AITBS Delhi-110051
2. International Trade and Food Security, Edited by F Brouwer, LEI - Wageningen UR, The Netherlands, P K Joshi, IFPRI, India. 2016.

| AECON 525 | INSTITUTIONAL ECONOMICS | 1 (1+0) |
|---|---|---|

**WHY THIS COURSE:** Institutions are involved in framing of economic development. The human behavior is governed by the institutions working in their environment. Thus, the student need to understand the institutions and their working.

**OBJECTIVE:** To develop critical and informed understanding about institutions, their role in the working of economy. Exposure of issues, policies & regulations and its application in agricultural system.

**COURSE OUTCOMES:**

After successful completion of this course the student will be able to-

1. Understand institutions and their roles in economic development.
2. Know about the policies and their issues in an institutions.

**ORGANIZATION OF THE COURSE:** The course is organised as follows-

**THEORY**

**Block 1- Introduction**

**UNIT-I:** Basics of Institutional Economics, Old and New Institutional Economics - Institutional Economics Vs Neo- classical Economics. Definition of institutions– Distinction between institutions and organizations – Institutional evolution.

**Block 2- Approaches**

**UNIT-I:** Institutional changes & Resource allocation, Institutional change and economic performance - national and international economic institutions. Transaction cost economics – Transaction costs and the allocation of resources. Transaction costs and efficiency. Asymmetric information - Moral hazard and Principal-Agent problem.

**UNIT-II:** Group and collective Approach, Free rider problem – path dependency – Interlinked transactions. Collective action and the elimination of free-rider problem - The logic of collective action and its role in reducing free rider problem – theory of Groups. Rent seeking – interest groups and policy formulation.

**Block 3- Law Protection and Institutions**

**UNIT-I**: Property rights, Economic analysis of property rights- property rights regimes – private property – State Property - Common property Resources (CPRs) – public goods and club goods.

**UNIT-II:** Agrarian Institutions, Special features of institutional arrangements in agriculture – Transaction costs in agriculture -Case Studies - Theories of agrarian institutions - tenancy institutions.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Case studies.
- Assignments (Group/individual).
- Group Discussions on Property rights

**SUGGESTED READING**

I. David W. Pearce –The dictionary of modern Economics.

## AECON 526 DEVELOPMENT ECONOMICS 2 (2+0)

**WHY THIS COURSE:** Development is more important than growth. The development of a nation ensures that condition of welfare prevails. The students has to understand different measures of development. How to measure them and relevant theories.

**OBJECTIVE:** To develop concept of growth and development. Methods and theories of measuring development. Study of different developed economies will give exposure towards measures to create economic upliftment.

**COURSE OUTCOMES:** After successful completion of this course, the student will be able to-

- Measure the development using different methods.
- Understand the theories of development and relate it to real world.

**ORGANIZATION OF THE COURSE:** The course is organised as follows:

**THEORY**

**Block 1- Introduction to Development Economics**

**UNIT-I**: Conceptions of Development, Development Economics– Scope and Importance- Economic development and economic growth- divergence in concept and approach- Indicators and Measurement of Economic Development –GNP as a measure of economic growth– New Measures of Welfare– NEW and MEW– PQLI –HDI – Green GNP - Criteria for under development –Obstacles to economic development– Economic and Non-Economic factors of economic growth-Development issues, poverty, inequality, unemployment and environmental degradation.

**Block 2- Theories and comparison**

**UNIT-I:** Theories of Economic growth and development, Classical theories- Adam smith - Ricardo-Malthus, Marx's theory of economic development; Schumpeter's theory, Approaches to development- low income equilibrium trap – critical minimum effort- The Strategy of economic development-Balanced vs. Unbalanced growth, choice of technique, investment criteria, big push theory, Rostow's stages of Economic Growth, unlimited supply of labour; social and technological dualisms; roles of capital accumulation, human capital and technological change in economic development, Models of economic growth Harrod-Domar, Kaldor, Mahalanobis, Lewis, FeiRanis, Input-Output, multisectoral models.

**UNIT-II:** Comparative Economic Development, Countries selected for case studies -USA, Japan, China and India; Overview of economic development is selected countries; agrarian surplus and the role of the peasantry in economic development; industrial revolution; division of labour, organisation of work and industrial production, the role of the State in developmental transition

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Case studies.
- Assignments (Group/individual).
- Group Discussions on inflation

**SUGGESTED READINGS**

1. Blaug. M.1986. Economic History and the History of Economic Thought
2. Hollis B chenery & TN Srinivasan Handbook of Development Economics
3. Robert E. Baldwin Economic Development and Growth. John Willey, New York.

## AECON 531 AGRICULTURAL FINANCE AND PROJECT MANAGEMENT 3 (2+1)

**WHY THIS COURSE:** Money is the fuel of driving all the economic activities. India is a land of small and marginal farmers. The financial conditions of the farmers is not so strong that they can finance themselves. They require credit to meet the requirements of inputs. Thus, the student should know the sources, principles involved and types of credit available. The institutions involved and on what grounds the finance is given to the farmer. What are the risks involved and how to overcome them.

**OBJECTIVE:** This course is designed with an objective to deliver knowledge of the principles, procedures, problems and policies relating to financing agricultural firms. In addition to this the students are also given knowledge about the research developments in the subject. The approach is analytic.

**COURSE OUTCOMES:** After the completion of the course the student will be able to-

1. Understand the key issues of finance in Agriculture.
2. Learn the techniques of assessing the worth of a project.

**ORGANIZATION OF THE COURSE:** The course is organised as follows:

**THEORY**

**Block 1- Introduction to Agricultural Finance**

**UNIT-I:** Basic concepts: A Review, Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending– Direct and Indirect Financing– Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's- NGO's, and SHG's.

**Block 2- Credit and Financial Analysis**

**UNIT-I:** Credit and its aspects, Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening.

**UNIT-II:** Financial analysis; Financial Decisions – Investment, Financing, Liquidity and Solvency. Preparation of financial statements - Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and Assessing the performance of farm/firm.

**Block 3- Project and Risk Management**

**UNIT-I:** Project Overview, Project Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques – Undiscounted measures. Time value of money -Use of discounted measures - B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Network Techniques -PERT and CPM.

**UNIT-II: Risk and its Management**

Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes - yield loss and weather based insurance and their applications.

**PRACTICAL**

Development of Rural Institutional Lending - Branch expansion, demand and supply of institutional agricultural credit and Over dues and Loan waiving- : An overview, Rural Lending Programmes of Commercial Banks, Lead Bank Scheme- Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions, Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through financial statements, Performance of Micro Financing Institutions- NGO's and Self-Help Groups, Identification and formulation of investment projects, Project appraisal techniques – Undiscounted Measures and their limitations. Project appraisal techniques – Discounted Measures, Network techniques – PERT and CPM for project management, Case Study Analysis of an Agricultural project, Financial Risk and risk management strategies – crop insurance schemes, Financial instruments and methods –E banking, Kisan Cards and core banking.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Case studies.
- Assignments (Group/individual).
- Group Discussions on inflation

**SUGGESTED READINGS**

1. Die Sollem, H. and Heady, E. O. (Ed.). Capital and Credit Needs in Changing Agriculture, Bauman.
2. Hopkins, A. Barry, Peter Jo, and Baker, C.B., Financial Management in Agriculture,
3. William G. Murray and Aaron G. Nelson, Iowa State University 1960 Agricultural Finance Agricultural Finance in India: Role of Commercial Banks, Charnjit Chanona, Marketing and Economics Research Bureau, New Delhi, 1969.
4. Gittinger, J. P. 1972, Economic analysis of agricultural projects, John Hopkins Univ. Press, Baltimore.
5. Little, I.M.D. and J.A. Mirrless 1974, Project appraisal and planning for developing countries, Oxford and IBH publishing Co. New Delhi.
6. Harberger, Arnold C 1972, Project Evaluation, collected papers, Macmillan.

## AECON 532 LINEAR PROGRAMMING 2 (1+1)

**THEORY**

**UNIT-I**: Decision Making- Concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.

**UNIT-II:** Simplex Method: Concept of simplex Method, solving profit maximization and cost minimizations problems. Formulation of farms and non-farm problems as linear programming models and solutions.

**UNIT-III:** Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.

**UNIT-IV:** Game Theory- Concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies, the rectangular game as Linear Programming.

**PRACTICAL**

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the simplex matrices for typical farm situations.

## AECON 533 COMMODITY FUTURE TRADING 2(2+0)

**WHY THIS COURSE:** Risk is involved in marketing. Price fluctuation is a very common phenomenon in agriculture marketing. In such situation selling of commodity in future market serves as a resort to insulate from this uncertainty. Thus, knowledge of futures market is helpful.

**OBJECTIVE:** To disseminate the knowledge about risk mitigating measures especially future trading. The future trading in agricultural commodities is increasing day by day therefore the role of SEBI, functioning of commodity exchanges are discussed.

**COURSE OUTCOMES**

After successful completion of this course, the student will be able to-

1. The basic concepts of commodity markets.
2. The national and international commodity markets.

**ORGANIZATION OF THE COURSE:** The course is organised as follows-

**Block 1- Introduction to commodity market**

**UNIT-I:** Concepts of commodity future trading, History and Evolution of commodity markets – Terms and concepts: spot, forward and futures Markets – factors influencing spot and future markets. Speculatory mechanism in commodity futures.

**Block 2- Techniques and Risks in Commodity Market**

**UNIT-I:** Technical aspects, Transaction and settlement – delivery mechanism - role of different agents- trading strategies -potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets.

**UNIT-II:** Risk and its Management, Risk in commodity trading, importance and need for risk management measures– managing market price risk: hedging, speculation, arbitrage, swaps - pricing and their features.

**Block 3- Commodity exchange and market analysis**

**UNIT-I:** Commodity Exchange– A review, Important global and Indian commodity exchanges - contracts traded – special features -Regulation of Indian commodity exchanges - FMC and its role.

**UNIT-II:** Analysis of commodity market, Fundamental Vs Technical analysis – construction and interpretation of charts and chart patterns for analyzing the market trend – Market indicators – back testing. Introduction to technical analysis software – analyzing trading pattern of different commodity groups.

**TEACHING METHODS/ ACTIVITIES**

- Lectures.
- Case studies.
- Assignments (Group/individual).
- Group Discussions.
- Power point presentations by students.

**SUGGESTED READINGS**


1. Kaufman PJ. The Concise Handbook of Futures Markets: Jhon Wiley & Sons
2. Purcell WD. Agricultural Futures and Options Principles and Strategies: MacMillan Publications Wasendorf RR & McCaffery All About Commodities from the Inside Out McGraw Hill.

# DEPARTMENT OF PLANT PHYSIOLOGY
# AGRICULTURE UNIVERSITY JODHPUR

**Semester wise Course Title and Credits : M.Sc. (Agri.) Plant Physiology**

| S. No. | Course Code | Course Title | Credit hrs. |
|---|---|---|---|
| | **Semester-I** | | |
| 1. | PP 511* | Principles of Plant Physiology I-Plant Water Relations and Mineral Nutrition | 3(2+1) |
| 2. | PP 512* | Principles of Plant Physiology-II: Metabolic Processes and Growth Regulation | 3(2+1) |
| 3. | PP 513 | Physiological and Molecular Responses of Plants to Abiotic Stresses | 3(2+1) |
| 4. | PP 514 | Hormonal Regulation of Plant Growth and Development | 3(2+1) |
| | **Semester-II** | | |
| 1. | PP 521* | Plant Developmental Biology: Physiological and Molecular Basis | 3(2+1) |
| 2. | PP 522* | Seed Physiology | 3(2+1) |
| 3. | PP 523 | Physiological and Molecular Mechanisms of Mineral Nutrient Acquisition and Their Functions | 3(2+1) |
| 4. | PP 524 | Physiology of Field Crops | 2(2+0) |
| | **Semester-III** | | |
| 1. | PP 531 | Photosynthetic Processes, Crop Growth and Productivity and Concepts of Crop Modeling | 3(2+1) |
| 2. | PP 532 | Physiology of Horticulture Crops | 2(2+0) |
| 3. | PP 534 | Phenotyping Physiological Processes | 2(2+0) |
| 4. | PP 535 | Crop Growth Regulation and Management | 2(2+0) |
| 5. | PP 591 | Master's Seminar | 1(1+0) |
| | **Semester-IV** | | |
| 1. | PP 598 | Comprehensive | NC |
| 2. | PP 599 | Masters Research | (30) |

*Core courses

## COURSE CONTENTS:

## PP 511 PRINCIPLES OF PLANT PHYSIOLOGY I - PLANT WATER RELATIONSAND MINERAL NUTRITION 3 (2+1)

**THEORY**

| S.No. | Blocks | Units | |
|---|---|---|---|
| 1. | Plant Water Relations | 1. | Soil and Plant Water Relations |
| | | 2. | Water Absorption and Translocation |
| | | 3. | Transpiration and Evaporative Cooling |
| | | 4. | Water Productivity and Water Use Efficiency |
| | | 5. | Moisture Stress and Plant Growth |
| 2. | Mineral Nutrition | 1. | Nutrient Elements and Their Importance |
| | | 2. | Nutrient Acquisition |
| | | 3. | Concept of Foliar Nutrition |

**BLOCK 1: PLANT WATER RELATIONS**

**UNIT-1: Soil and Plant Water Relations**

- Water and its importance; Molecular structure of water; Properties and functions of water.
- Concept of water potential; Plant cell and soil water potential and their components; Methods to determine cell and soil water potential; Concept of osmosis and diffusion.

- Soil physical properties and water availability in different soils; Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance.

**UNIT-2: Water Absorption and Translocation**

- Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation; Theories explaining water absorption and translocation; Aquaporins.
- Mycorrhizal association and its relevance in water mining.

**UNIT-3: Transpiration and Evaporative Cooling**

- Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance.
- Energy balance: Solar energy input and output at crop canopy level.
- Stomata- its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure.
- Anti-transpirants and their relevance in agriculture.

**UNIT-4: Water Productivity and Water Use Efficiency**

- WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE.

**UNIT-5: Moisture Stress and Plant Growth**

- Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level.
- Drought indices and drought tolerance, Strategies Drought tolerance traits.

**BLOCK 2: MINERAL NUTRITION**

**UNIT-1: Nutrient Elements and Their Importance**

- Role of mineral nutrients in plant's metabolism; Essential elements and their classification; Beneficial elements; factors influencing the nutrients availability; critical levels of nutrients.
- Functions of mineral elements in plants.
- Deficiency and toxicity symptoms in plants.

**UNIT-2: Nutrient Acquisition**

- Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters; xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels.
- Role of mycorrhiza, root exudates and PGPRs in plant nutrient acquisition.

**UNIT-3: Concept of Foliar Nutrition**

- Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.

**PRACTICAL**

1. Standard solutions and preparation of different forms of solutions;
2. Studies on the basic properties of water;
3. Demonstration of surface tension of water and other solvents;
4. Measurement of plant water status: Relative water content and rate of water loss;
5. Determination of water potential through tissue volume and Chardakov's test;
6. Determination of water potential using pressure bomb, osmometer, psychrometer;
7. Determination of soil moisture content and soil water potential;
8. Use of soil moisture probes and soil moisture sensors;
9. Measurement of transpiration rate in plants; use of porometry;
10. Measurement of CCATD and its relevance;
11. Demonstration and use of anti-transpirants to reduce transpiration;
12. Influence of potassium and ABA on stomatal opening and closing respectively;
13. Deficiency and toxicity symptoms of nutrients;
14. Effect of water stress on plant growth and development.

**Suggested Readings:**

**BLOCK 1:**

**UNIT-1:**

1. Jordi, M. V. and Núria, G. F. 2017. Water potential regulation, stomatal behaviour and hydraulic transport under drought: deconstructing the iso/anisohydricconcept Plant, Cell and Environment **40**,962–976.
2. Mangrich, S., E. M. C. Cardoso, M. E. Doumer, L. P. C. Romão, M. Vidal, A. Rigol, E. H. Novotny. Improving the Water Holding Capacity of Soils of Northeast Brazil by Biochar Augmentation. Chapter **16**, pp 339–354

**UNIT-2:**

1. McElrone, A. J., Choat, B., Gambetta, G. A. and Brodersen, C. R. 2013 Water Uptake and Transport in Vascular Plants. Nature Education Knowledge **4(5)**:6.
2. Hodson, R.C. and J. Acuff. 2006. Water transport in plants: anatomy and physiology. Pages 163-183, in Tested Studies for Laboratory Teaching, Volume **27** (M.A. O'Donnell, Editor). Proceedings of the 27th Workshop/ Conference of the Association for Biology Laboratory Education (ABLE), 383 pages.

**UNIT-3:**

1. Caspar, C.C. Chater, Robert S. Caine, Andrew J. Fleming, Julie E. G. 2017. Plant Physiology Jun, **174 (2)** 624-638; DOI: 10.1104/pp.17.00183
2. Petra Dietrich, Dale Sanders, Rainer, H. 2001. The role of ion channels in light dependent stomatal opening, *Journal of Experimental Botany*, Volume **52**, Issue 363., Pages 1959–1967, https://doi.org/10.1093/jexbot/52.363.1959

**UNIT-4:**

1. Sreeman, S.M., Vijayaraghavareddy, P., Sreevathsa, R., Rajendrareddy, S., Arakesh, S., Bharti, P., Dharmappa, P., Soolanayakanahally, R., 2018. Introgression of Physiological Traits for a Comprehensive Improvement of Drought Adaptation in Crop Plants. *Front. Chem.* **6**, 92.

**UNIT-5:**

1. Seyed Yahya Salehi-Lisar Hamideh Bakhshayeshan-Agdam, 2016. Drought Stress in Plants: Causes, Consequences, and Tolerance. *Drought Stress Tolerance in Plants*, Vol **1** pp 1-16.

**BLOCK 2:**

**UNIT-1:**

1. Pandey, Renu. (2015). Mineral Nutrition of Plants. 10.1007/978-81-322-2286-6_20.
2. Barker A. V. and D. J. Pilbeam (2015). Handbook of Plant Nutrition, 2nd Edition. Books in Soils, Plants and the Environment Series, the 2nd Edition, CRC Press.

**UNIT-2:**

1. Vatansever, R., Ozyigit, I. I., and Filiz, E. (2017). Essential and beneficial trace elements in plants, and their transport in roots: a review. *Applied biochemistry and biotechnology*, **181(1)**: 464-482.
2. Tahat, M. M., and Sijam, K. (2012). Arbuscularmycorrhizal fungi and plant root exudates bio-communications in the rhizosphere. *African Journal of Microbiology Research*, **6(46)**: 7295-7301.

**UNIT-3:**

1. Rajasekar, M., D. Udhaya Nandhini and Suganthi S. (2017). Supplementation of Mineral Nutrients through Foliar Spray– A Review. Int. J. Curr. Microbiol. App. Sci. **6(3)**: 2504-2513.
2. Alshaal, Tarek and El-Ramady, Hassan. (2017). Foliar application: from plant nutrition to biofortification. Environment, Biodiversity and Soil Security.

**General Source of Information:**

- Taiz T, Zeiger E and Max Mller IM, 2018, Fundamentals of Plant Physiology.
- Taiz L and Zeiger E. 2015. Plant Physiology and development.6th Ed.
- Salisbury FB and Ross C. 1992 (4th Ed.) Plant Physiology.
- Emanuel Epstein and Arnold J. Bloom. 2004, Mineral nutrition of plants: principles and perspectives. 2nd Ed.
- Hopkins WG and Huner NPA. 2004. Introduction to Plant Physiology.
- Kramer, P. J., Water relations of plants .
- Kirkham, M. B., Principles of soil and plant water relations Hopkins WG 2008, Introduction to plant physiology.

**PP 512 PRINCIPLES OF PLANT PHYSIOLOGY-II: METABOLIC PROCESSES AND GROWTH REGULATION 3(2+1)**

**THEORY**

| S.No. | Blocks | Units | |
|---|---|---|---|
| 1. | Metabolic processes and growth regulation | 1 | Carbon Metabolism – Photochemical Processes |
| | | 2. | Carbon Metabolism: Biochemical Processes |
| | | 3. | Carbon Metabolism: Respiration |
| | | 4. | Product Synthesis and Translocation Leading to Crop Growth |
| | | 5. | Nitrogen Assimilation and Protein Synthesis |
| | | 6. | Lipid Metabolism and Secondary Metabolites |
| | | 7. | Hormonal Regulation of Plant Growth and Development |
| | | 8. | Synthetic Growth Promoters |
| | | 9. | Morphogenesis and Reproductive Phase |

**BLOCK 1: METABOLIC PROCESSES AND GROWTH REGULATION**

**UNIT-1: Carbon Metabolism – Photochemical Processes**

- Chloroplast ultrastructure with special mention of lamellar system.
- Excitation, electron and proton transfers and their relevance in energy conservation.
- Concepts of pigment systems and generation of powerful reductant and oxidant .
- Water oxidation, Water-water cycle and other aspects of electron transfer .

**UNIT-2: Carbon Metabolism: Biochemical Processes**

- $CO_2$ diffusion mechanisms and diffusive conductances, concept of Ci determining Photosynthesis.
- RuBisCO enzyme kinetics and Calvin cycle mechanisms, Regulation of Calvin cycle and metabolite fluxes.
- Photorespiration: the advantages and inefficiencies of photosynthesis because of photorespiration.
- Concepts of $CO_2$ concentrating mechanisms (CCM) and spatial and temporal differences in carboxylation.
- Ecological aspects of C4and CAM photosynthesis.
- Product synthesis, Starch and Sucrose biosynthesis.

**UNIT-3: Carbon Metabolism: Respiration**

- Mitochondrial organization and functions.
- Aspects of Glycolysis, TCA cycle and mitETC. Relevance of growth and maintenance respiration.
- Concepts of CN resistance respiration – Alternate and SHAM sensitive ETC.

**UNIT-4: Product Synthesis and Translocation Leading to Crop Growth**

- Phloem loading and sugar transporting, concepts of bi-directional transport of sugars and other metabolites.
- Source-Sink relationship and modulation of photosynthesis.
- Concepts and definitions of Growth and Differentiation.
- Growth and yield parameters, NAR, CGR, HI and concepts of LAI, LAD.

**UNIT-5: Nitrogen Assimilation and Protein Synthesis**

- Nitrgen fixation process and its types.
- Nitrate reduction and assimilation GS-GOGAT process for amino acid synthesis.
- Inter-Dependence of carbon assimilation and nitrogen metabolisms.

**UNIT-6: Lipid Metabolism and Secondary Metabolites**

- Storage, protective and structural lipids.
- Biosynthesis of fatty-acids, diacyl and triacyl glycerol, fatty acids of storage lipids.
- Secondary metabolites and their significance in plant defense mechanisms.

**UNIT-7: Hormonal Regulation of Plant Growth and Development**

- Growth promoting and retarding hormones: biosynthesis, transport, conjugation.
- Mode of action of these hormones and their application in plant physiology.

**UNIT-8: Synthetic Growth Promoters**

- Different synthetic hormones: Salicylic acid, strigolactones *etc.*
- Roles and biological activities of various synthetic hormones.
- Commercial application of hormones to maximize growth and productivity.

**UNIT-9: Morphogenesis and Reproductive Phase**

- Photoperiodism: Phytochromes, their structure and function.
- Circadian rhythms.
- Blue light receptors: Cryptochrome and morphogenesis.
- Vernalization and its relevance in germination.

**PRACTICAL**

1. Radiant energy measurements;
2. Separation and quantification of chlorophylls;
3. Separation and quantification of carotenoids;
4. $O_2$ evolution during photosynthesis;
5. Anatomical identification of $C_3$ and $C_4$ plants;
6. Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration;
7. Measurement of respiration rates;
8. Estimation of reducing sugars, starch;
9. Estimation of $NO_3$, free amino acids in the xylem exudates, quantification of soluble proteins;
10. Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene;
11. Demonstration of photoperiodic response of plants in terms of flowering.

**Suggested Readings:**

**Block 1:**

**UNIT-1:**

1. Kirchhoff, H. (2019). Chloroplast ultrastructure in plants, New Phytologist. https://doi.org/10.1111/nph.15730
2. Jafari, T., Moharreri, E., Amin, A., Miao, R., Song, W., and Suib, S. (2016). Photocatalytic water splitting-the untamed dream: a review of recent advances. Molecules, **21(7)**: 900**.**

**UNIT-2:**

1. Jensen E, Cle´ment R, Maberly SC, Gontero B. (2017). Regulation of the Calvin– Benson–Bassham cycle in the enigmatic diatoms: biochemical and evolutionary variations on an original theme. Phil. Trans. R. Soc. B 372: 20160401. http://dx.doi.org/10.1098/rstb.2016.0401
2. Raven, J. A., and Beardall, J. (2015). The ins and outs of $CO_2$. *Journal of experimental botany*, **67(1):** 1-13.
3. Rae, B. D., Long, B. M., Förster, B., Nguyen, N. D., Velanis, C. N., Atkinson, N. .and McCormick, A. J. (2017). Progress and challenges of engineering a biophysical CO2-concentrating mechanism into higher plants. *Journal of Experimental Botany*, **68(14):** 3717-3737.

**UNIT-3:**

1. Hagemann, M., Weber, A. P., andEisenhut, M. (2016). Photorespiration: origins and metabolic integration in interacting compartments. Journal of experimental botany, **67(10):** 2915.
2. Kühlbrandt, W. (2015). Structure and function of mitochondrial membrane protein complexes. *BMC Biology*, **13(1):** 89.

**UNIT-4:**

1. Liesche, J., and Patrick, J. (2017). An update on phloem transport: a simple bulk flow under complex regulation. *Research*, 6.
2. Jensen, K. H., Berg-Sørensen, K., Bruus, H., Holbrook, N. M., Liesche, J., Schulz, A., and Bohr, T. (2016). Sap flow and sugar transport in plants. *Reviews of Modern Physics*, **88(3):** 035007.
3. Julius, B. T., Leach, K. A., Tran, T. M., Mertz, R. A., and Braun, D. M. (2017). Sugar transporters in plants: new insights and discoveries. *Plant and Cell Physiology*, **58(9)**: 1442-1460.

**UNIT-5:**

1. Rao, D. L. N. (2014). Recent advances in biological nitrogen fixation in agricultural systems. *In Proc. Indian Natl. Sci. Acad*, (Vol. **80**, No. **2**, pp. 359-378.
2. Hoffman, B. M., Lukoyanov, D., Yang, Z. Y., Dean, D. R., and Seefeldt, L. C. (2014).

Mechanism of nitrogen fixation by nitrogenase: the next stage. *Chemical reviews*, **114(8)**: 4041-4062.
3. Mus, F., Crook, M. B., Garcia, K., Costas, A. G., Geddes, B. A., Kouri, E. D.andUdvardi, M. K. (2016). Symbiotic nitrogen fixation and the challenges to its extension to nonlegumes. *Appl. Environ. Microbiol.*, **82(13)**: 3698-3710.

**UNIT-6:**
1. Pagare, S., Bhatia, M., Tripathi, N., Pagare, S., and Bansal, Y. K. (2015). Secondary metabolites of plants and their role: Overview. *Curr Trends Biotechnol Pharm*, **9(3)**: 293-304.
2. Jain C, Khatana S and Vijayvergia R: Bioactivity of secondary metabolites of various plants: a review. *Int J Pharm Sci and Res* 2019; **10(2)**: 494-04. doi: 10.13040/IJPSR.0975-8232.10(2).494-04.

**UNIT-7:**
1. Li, C., Li, J., Chong, K., Harter, K., Lee, Y., Leung, J.,and Schroeder, J. (2016). Toward a molecular understanding of plant hormone actions. *Molecular plant*, **9(1)**: 1-3.
2. Eckardt, N. A. (2015). The plant cell reviews dynamic aspects of plant hormone signaling and crosstalk.
3. Jiang, K., andAsami, T. (2018). Chemical regulators of plant hormones and their applications in basic research and agriculture. *Bioscience, biotechnology and biochemistry*, **82(8)**: 1265-1300.

**UNIT-8:**
1. Zwanenburg, B., Pospíšil, T., and Zeljković, S. Ć. (2016). Strigolactones: new plant hormones in action. *Planta*, **243(6)**: 1311-1326.
2. Kumar, R., Khurana, A., and Sharma, A. K. (2014). Role of plant hormones and their interplay in development and ripening of fleshy fruits. *Journal of Experimental Botany*, **65(16)**: 4561-4575.
3. Gururani, M., Mohanta, T., and Bae, H. (2015). Current understanding of the interplay between phytohormones and photosynthesis under environmental stress. *International journal of molecular sciences*, **16(8)**: 19055-19085.

**UNIT-9:**
1. Song, Y. H., Shim, J. S., Kinmonth-Schultz, H. A., and Imaizumi, T. (2015). Photoperiodic flowering: time measurement mechanisms in leaves. *Annual Review of Plant Biology*, **66**: 441-464.
2. Sanchez, S. E., and Kay, S. A. (2016). The plant circadian clock: from a simple timekeeper to a complex developmental manager. *Cold Spring Harbor Perspectives in Biology*, **8(12)**:a 027748.

**GENERAL TEXT BOOKS**
1. Plant Physiology, Taiz, Lincoln, Zeiger, Eduardo Origanl American edition published by Sinauer Associates, Inc., 2006; 4th ed., 2007, XXVI, ISBN: 978-3-8274-1865-4; © Springer.
2. Plant Physiologyby Frank Boyer Salisbury and Cleon Ross.
3. Introduction to Plant Physiology 3e (Wie)by William G. Hopkins.

## PP 513 PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES 3(2+1)

**THEORY**

| S.No. | Blocks | Units | |
|---|---|---|---|
| 1 | Abiotic Stresses | 1. | Introduction to Abiotic Stresses |
| 2 | Drought Stress | 1. | Moisture Stress Responses in Plants |
| | | 2. | Stress Perception and Molecular Responses of Plants to Drought Stress |
| | | 3. | Plant Adaptive Mechanisms to Drought |
| | | 4. | Approaches to Improve Drought Tolerance |
| 3 | Salt, Heavy Metal,Water Logging,Temperature and Light Stress | 1. | Salt Stress |
| | | 2. | Heavy Metal Stress and Water Logging |
| | | 3. | Temperature and Light Stress |

**BLOCK 1: ABIOTIC STRESSES**

**UNIT-1: Introduction to Abiotic Stresses**

- Abiotic stresses major constraints to realize potential yields of crop plants, yield losses.
- Drought prone areas in India- Frequency of occurrence of drought, Rainfed- *Kharif*, *Rabi*, Areas affected by salinity, heavy metals, water logging, high temperature scenario due to global warming.

**BLOCK 2: DROUGHT STRESS**

**UNIT-1: Moisture Stress Responses in Plants**

- Drought-characteristic features; water potential in the soil-plant-air continuum.
- Physiological and biochemical processes affected by drought.Oxidative stress-generation of ROS and other cytotoxic compounds, their effect on cellular process.
- Effect on total carbon gain- decrease in photosynthetic area and function, protein turn over and lipid characters, phenology-reproductive aspects, critical stages.

**UNIT-2: Stress Perception and Molecular Responses of Plants to Drought Stress**

- Stress perception andsignal transduction leading to expression of regulatory genes, stress specific kinases, stress specific transcription factors, functional genes ssociated with adaptive mechanisms.

**UNIT-3: Plant Adaptive Mechanisms to Drought**

**a. Escape and desiccation avoidance mechanism**

- Concept of stress escape- exploiting genetic variability in phenology, Drought avoidance mechanisms- Maintenance of cell turgor, water mining by root characters.
- Moisture conservation- Regulation of transpiration- traits reducing heat load, Stomatal factors guard cell metabolism, moisture conservation by waxes.
- Water use efficiency (WUE) and concept of water productivity- regulation of transpiration efficiency-stomatal conductance, mesophyll efficiency, relevance of WUE and Passioura's model.

**b. Desiccation tolerance- Concept of acquired tolerance**

- Decreased turgor mediated upregulation of cellular tolerance mechanisms, Osmolytes, managing cytotoxic compounds, ROS, RCC, scavenging - enzymatic and non-enzymatic, protein turnover, stability, chaperones, membrane stability, photo-protection of chlorophylls.

**UNIT-4: Approaches to Improve Drought Tolerance**

- Development of genetic resources- donor genotypes for specific traits, Genomic resources- genes, QTL's regulating adaptive mechanisms, Conventional, transgenic and molecular breeding approaches to improve relevant adaptive traits, concept of trait introgression

**BLOCK 3: SALT, HEAVY METAL, WATER LOGGING, TEMPERATURE AND LIGHT TRESS**

**UNIT-1: Salt Stress**

- Soil salinity- Effect of salt stress, ionic and osmotic effects; species variation in salt tolerance; glycophytes and halophytes, Salt tolerance mechanisms- exclusion, extrusion and compartmentalization, Signaling during salt stress - SOS pathway, Approaches to improve salt tolerance.

**UNIT-2: Heavy Metal Stress and Water Logging**

- Heavy metal toxicity in plants (eg., Al, Cd), tolerance mechanisms and approaches to improve.
- Plant response to water logging, role of hormones- ethylene, mechanism of tolerance and approaches to improve.

**UNIT-3:Temperature and Light Stress**

- High and low temperatures; effect on plants; adaptive mechanisms, evaporation cooling, concept of cellular tolerance, protein stability, chaperones, HSPs, HSFs, membranes.
- High light and high ionizing radiation- photo oxidation and photo-inhibition; mechanisms of tolerance, plant adaptation to low light, concept of shade avoidance response (SAR)

**PRACTICAL**

1. Measurement of soil and plant water status;
2. Drought stress imposition and measurement of physiological and biochemical changes in plants under stress –gas exchange and fluorescence measurements;
3. Determination of water use efficiency as a drought resistant trait;
4. Drought Susceptibility Index (DSI) -precise field technique to identify productive genotypes under stress;
5. Approaches to quantify root characters;

6. Determination of stomatal parameters and canopy temperature as a reflection of transpiration and root activity;
7. Determination of Salinity Tolerance Index;
8. Studying acclimation response - Temperature induction response;
9. Heat tolerance and membrane integrity- Sullivans heat tolerance test;
10. Quantification of osmolytes – proline under stress;
11. Oxidative stress imposition- Quantification of oxidative stress;
12. Quantification of ROS under stress;
13. Estimation of ABA content in leaf and root tissues under stress;
14. Determination of Sodium and Potassium in plant tissue grown under salt stress;
15. Estimation of antioxidant enzymes.

**SUGGESTED READINGS**

**Block 1:**
**UNIT-1:**


1. Plant Physiology Book by Eduardo Zeiger and Lincoln Taiz.
2. Plant physiology Book by Frank B. Salisbury, Cleon W. Ross Salisbury, Frank B.
3. Pereira A (2016) Plant Abiotic Stress Challenges from the Changing Environment. Front. Plant Sci. 7:1123. doi: 10.3389/fpls.2016.01123
4. Sergey Shabala, 2012. Plant Stress Physiology. https://www.mapsofindia.com/maps/india/drought-prone-areas.html


**Block 2: UNIT-1:**


1. Abid, M., Ali, S., Qi, L.K., Zahoor, R., Tian, Z., Jiang, D., Snider, J.L. and Dai, T., 2018. Physiological and biochemical changes during drought and recovery periods at tillering and jointing stages in wheat (*Triticum aestivum* L.). *Scientific reports*, **8(1)**: 4615.
2. Fathi, Amin and Barari, Davood. (2016). Effect of Drought Stress and its Mechanism in Plants. *International Journal of Life Sciences*. **10**: 1. 10.3126/ijls.v10i1.14509.
3. Ashwani Pareek, Sopory. S.K, Bohnert. H.J. and Govindjee 2010. Abiotic Stress Adaptation in Plants, Springer, The Netherlands
4. Dumont, S. and Rivoal, J. 2019. Consequences of oxidative stress on plant glycolytic and respiratory metabolism. *Frontiers in Plant Science*, **10**.
5. Mittler, R. 2002. Oxidative stress, antioxidants and stress tolerance. *Trends in Plant Science*, **7(9)**: 405-410.
6. Demidchik, V. 2015. Mechanisms of oxidative stress in plants: from classical chemistry to cell biology. *Environmental and Experimental Botany*, **109**: 212-228.
7. Das, K. and Roychoudhury, A., 2014. Reactive oxygen species (ROS) and response of antioxidants as ROS-scavengers during environmental stress in plants. *Frontiers in Environmental Science*, **2**: 53.
8. Yadav, Praduman, Sunil kumar and Veena Jain. (2016). Recent Advances in Plant Stress Physiology. Daya Publishing House, New Delhi.


**UNIT-2:**


1. GyanaRanjan Rout and AnathBandhu Das. 2013. Molecular Stress physiology of plants. Springer, India.
2. Combined Stresses in Plants Physiological, Molecular, and Biochemical Aspects Editors: Mahalingam, Ramamurthy (Ed.) 2015.
3. Lata, Charu and Muthamilarasan, Mehanathan and Prasad, Manoj. (2015). Drought Stress Responses and Signal Transduction in Plants. In elucidation of abiotic stress signaling in plants (PP.195-225). Springer, New York,Ny. DOI: 10.1007/978-1-4939-2540-7_7.
4. Zhu, J.K., 2016. Abiotic stress signaling and responses in plants. Cell, **167(2)**: 313-324.
5. Osakabe, Y., Yamaguchi-Shinozaki, K., Shinozaki, K. and Tran, L.S.P., 2013. Sensing the environment: key roles of membrane-localized kinases in plant perception and response to abiotic stress. *Journal of Experimental Botany*, **64(2)**: 445-458.
6. Xiong, L. and Zhu, J.K., 2001. Abiotic stress signal transduction in plants: molecular and genetic perspectives. *Physiologia plantarum*, **112(2)**: 152-166.
7. Gill, S.S., Anjum, N.A., Gill, R. and Tuteja, N., 2016. Abiotic Stress signaling in plants–an overview. *Abiotic Stress Response in Plants*, **3**: 1-12.
8. de Vasconcelos, M.W.P.L., Menguer, P.K., Hu, Y., Revers, L.F. and Sperotto, R.A., 2016. Stress

signaling responses in plants. *BioMed Research International*, 2016.

**UNIT-3:**

1. Khan, A., Pan, X., Najeeb, U., Tan, D.K.Y., Fahad, S., Zahoor, R. and Luo, H., 2018. Coping with drought: stress and adaptive mechanisms, and management through cultural and molecular alternatives in cotton as vital constituents for plant stress resilience and fitness. *Biological Research*, **51(1)**: 47.
2. Abobatta, Waleed. (2019). Drought adaptive mechanisms of plants -a review. *Adv. Agr. Environ Sci.*, **2(1)**: 42-45. DOI: 10.30881/aaeoa.00021.
3. Basu, S., Ramegowda, V., Kumar, A. and Pereira, A., 2016. Plant adaptation to drought stress. F1000*Research*, **5**.
4. Gilbert, M.E. and Medina, V., 2016. Drought adaptation mechanisms should guide experimental design. *Trends in Plant Science*, **21(8)**: 639-647.
5. Kamanga RM, Mbega E, Ndakidemi P (2018) Drought Tolerance Mechanisms in Plants: Physiological Responses Associated with Water Deficit Stress in Solanum lycopersicum. *Adv Crop Sci Tech* **6**: 362. DOI: 10.4172/2329-8863.1000362
6. Farrant, Jill and Cooper, Keren and Nell, J. (2012). Desiccation Tolerance, Drought Stress Tolerance in Plants, Vol **1**, Physiology and Biochemistry, Editors: Hossain, M.A., Wani, S.H., Bhattacharjee, S., Burritt, D.J., Tran, L.-S.P. (Eds.)
7. Prakash, M. and Dr.K.Balakrishnan. 2014. Abiotic Stress tolerance in crop plants. Satish Serial Publishing House. Delhi. ISBN: 978-93-81226-92-6.
8. Plant Tolerance to Individual and Concurrent Stresses Editors: Senthil-Kumar, Muthappa (Ed.) 2017.
9. Fernando, V.D. and Schroeder, D.F., 2016. Role of ABA in Arabidopsis salt, drought, and desiccation tolerance. In Abiotic and Biotic Stress in Plants-Recent Advances and Future Perspectives. IntechOpen.
10. Le Gall, H., Philippe, F., Domon, J.M., Gillet, F., Pelloux, J. and Rayon, C., 2015. Cell wall metabolism in response to abiotic stress. *Plants*, **4(1)**: 112-166.
11. Hasanuzzaman, M., Nahar, K., Alam, M., Roychowdhury, R. and Fujita, M., 2013. Physiological, biochemical, and molecular mechanisms of heat stress tolerance in plants. *International Journal of Molecular Sciences*, **14(5)**: 9643-9684.
12. Khan, M.I.R., Fatma, M., Per, T.S., Anjum, N.A. and Khan, N.A., 2015. Salicylic acid-induced abiotic stress tolerance and underlying mechanisms in plants. *Frontiers in Plant Science*, **6**: 462.

**UNIT-4:**

1. Tuberosa, Roberto and Salvi, Silvio. (2006). Genomic based approaches to improve drought tolerance in crops. *Trends Plant Sci.* **11**: 1260-1285.
2. Ali, A., Ali, Z., Quraishi, U.M., Kazi, A.G., Malik, R.N., Sher, H. and Mujeeb-Kazi, A., 2014. Integrating physiological and genetic approaches for improving drought tolerance in crops. *In Emerging technologies and management of crop stress tolerance* (pp. 315-345). Academic Press.
3. Sahebi, M., Hanafi, M.M., Rafii, M.Y., Mahmud, T.M.M., Azizi, P., Osman, M., Abiri, R., Taheri, S., Kalhori, N., Shabanimofrad, M. and Miah, G., 2018. Improvement of drought tolerance in rice (Oryza sativa L.): Genetics, genomic tools, and the WRKY gene family. *Bio Med Research International*, 2018.
4. Manavalan, L.P., Guttikonda, S.K., Phan Tran, L.S. and Nguyen, H.T., 2009. Physiological and molecular approaches to improve drought resistance in soybean. *Plant and Cell Physiology*, **50(7)**: 1260-1276.
5. Shah, A.A., Salgotra, R.K., Wani, S.A. and Mondal, S.K., 2017. Breeding and genomics approaches to increase crop yield under drought stress in climate change scenario. *European Journal of Experimental Biology*, **7(4)**: pp.1-7.
6. Dixit, S., Yadaw, R.B., Mishra, K.K. and Kumar, A., 2017. Marker-assisted breeding to develop the drought-tolerant version of Sabitri, a popular variety from Nepal. *Euphytica*, **213(8)**: 184.
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**Block 2:**

**UNIT-1:**


1. Gupta, B. and Huang, B., 2014. Mechanism of salinity tolerance in plants: physiological, biochemical, and molecular characterization. *International Journal of Genomics*, 2014.
2. Zhu, J.K., 2001. Plant salt tolerance. *Trends in Plant Science*, **6(2)**: 66-71.
3. Moghimi, A., Yang, C., Miller, M.E., Kianian, S.F. and Marchetto, P.M., 2018. A novel approach to assess salt stress tolerance in wheat using hyperspectral imaging. *Frontiers in Plant Science*.
4. Isayenkov, S.V. and Maathuis, F.J., 2019. Plant Salinity Stress: Many Unanswered Questions Remain. *Frontiers in Plant Science*, **10**.
5. Tuteja, N., 2007. Mechanisms of high salinity tolerance in plants. In Methods in enzymology (Vol. **428**, pp. 419-438). Academic Press.
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7. Rasool, Saiema and Hameed, Asiya and Azooz, Mohamed and Rehman, Muneeb and O. Siddiqi, T and Ahmad, Parvaiz. (2013). Salt Stress: Causes, Types and Responses of Plants..
8. Negrão, S., Schmöckel, S.M. and Tester, M., 2017. Evaluating physiological responses of plants to salinity stress. *Annals of Botany*, **119(1)**: 1-11.


**UNIT-2:**


1. Fukao, T., Barrera-Figueroa, B.E., Juntawong, P. and Peña-Castro, J.M., 2019. Submergence and Waterlogging Stress in Plants: A Review Highlighting Research Opportunities and Understudied Aspects. *Frontiers in Plant Science*, **10**: 340.
2. Emamverdian, A., Ding, Y., Mokhberdoran, F. and Xie, Y., 2015. Heavy metal stress and some mechanisms of plant defense response. *The Scientific World Journal*, 2015.
3. Mani, A. and Sankaranarayanan, K., 2018. Heavy Metal and Mineral Element-Induced Abiotic Stress in Rice Plant. *In Rice Crop-Current Developments*. IntechOpen.
4. Barceló, Juan and Poschenrieder, Charlotte. (2008). Plant Water Relations as Affected by Heavy Metal Stress: A Review. *Journal of Plant Nutrition*, **13**: 1-37.
5. Regulation of root traits for internal aeration and tolerance to soil water logging-flooding stress. Takaki Yamauchi, Timothy D. Colmer, Ole Pedersen, Mikio Nakazono, Plant physiology, 2018, **176(2)**.


**UNIT-3:**


1. Szymańska, R., Ślesak, I., Orzechowska, A. and Kruk, J., 2017. Physiological and biochemical responses to high light and temperature stress in plants. *Environmental and Experimental Botany*, **139**: pp.165-177.
2. Maduraimuthu, Djanaguiraman and Prasad, P. V. Vara. (2014). High temperature stress..
3. Nahar, K., Hasanuzzaman, M., Ahamed, K.U., Hakeem, K.R., Ozturk, M. and Fujita, M., 2015. Plant responses and tolerance to high temperature stress: role of exogenous phytoprotectants. *In Crop Production and Global Environmental issues* (pp. 385-435). Springer, Cham.
4. Mathur, S., Agrawal, D. and Jajoo, A., 2014. Photosynthesis: response to high temperature stress. Journal of Photochemistry and Photobiology B: Biology, **137**: 116-126.
5. Ort, D.R., 2001. When there is too much light. Plant physiology, **125(1)**: 29-32.
6. Demmig-Adams, B. and Adams Iii, W.W., 1992. Photoprotection and other responses of plants to high light stress. *Annual Review of Plant Biology*, **43(1)**: 599-626.
7. Dietz, K.J., 2015. Efficient high light acclimation involves rapid processes at multiple mechanistic levels. *Journal of Experimental Botany*, **66(9)**: 2401-2414.


## PP 514 HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT 3 (2+1)

**THEORY**

| No. | Blocks | Units | |
|---|---|---|---|
| 1. | Plant Growth and Development : Hormonal regulation | 1. | Introduction to Plant Hormones |
| | | 2. | Plant Hormones - Discovery and Metabolism |
| | | 3. | Physiological Role of Hormones in Plant Growth and Development |
| | | 4. | Endogenous Growth Substances other than Hormones |
| | | 5. | Hormone Signaling |

| | | | |
|---|---|---|---|
| | | 6. | Key Genes Regulating Hormone Levels and Functions |
| | | 7. | Crosstalk of Hormones in Regulation of Plant Growth and Development Processes |
| | | 8. | Practical Utility of Growth Regulators in Agriculture and Horticulture |

**BLOCK 1: PLANT GROWTH AND DEVELOPMENT: HORMONAL REGULATION**

**UNIT-1: Introduction to Plant Hormones**

- Growth, differentiation and development regulated by plant growth substances.
- Definition and classification of growth regulating substances: Classical hormones.
- Definition and classification of growth regulating substances: Endogenous growth substances other than hormones, Synthetic chemicals.

**UNIT-2: Plant Hormones - Discovery and Metabolism**

- Discovery, biosynthetic pathways and metabolism of Auxin, Gibberellins, Cytokinins, Abscisic acid, Ethylene, Brassinosteroids and Strigolactones.

**UNIT-3: Physiological Role of Hormones in Plant Growth and Development**

- Physiological functions of Auxin and use of mutants and transgenic plants in elucidating the physiological functions.
- Physiological functions of Gibberellins and use of mutants and transgenic plants in elucidating the physiological functions.
- Physiological functions of Cytokinins and use of mutants and transgenic plants in elucidating the physiological functions.
- Physiological functions of Abscisic acid and use of mutants and transgenic plants in elucidating the physiological functions.
- Physiological functions of Ethylene and use of mutants and transgenic plants in elucidating the physiological functions.
- Physiological functions of Brassinosteroids and Strigolactones and use of mutants and transgenic plants in elucidating the physiological functions.
- Discovery, biosynthetic pathways metabolism and physiological roles of Salicylic acid and Peptide hormones.

**UNIT-4: Endogenous Growth Substances other than Hormones**

- Discovery, biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins.
- Discovery, biosynthetic pathways metabolism and physiological roles of Jasmonates and Tricontanol.
- Discovery, biosynthetic pathways metabolism and physiological roles of systemins Concept of death hormone.
- Recent developments in elucidating responses of Salicylic acid, Peptide hormones and Polyamines at physiological and molecular level.
- Recent developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricontanol at physiological and molecular level.

**UNIT-5: Hormone Signaling**

- Hormone signal perception, transduction - Receptors, components and mechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid).
- Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones).
- Advances in elucidating the structure and function of receptors and signaling components of important hormones.

**UNIT-6: Key Genes Regulating Hormone Levels and Functions**

- Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies.

**UNIT-7: Crosstalk of Hormones in Regulation of Plant Growth and Development Processes**

- Crosstalk of Hormones in Regulation of Plant Growth and Development Processes: Floral transition, reproductive development, Shoot and root apical meristem development.

**UNIT-8: Practical Utility of Growth Regulators in Agriculture and Horticulture**

- Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings,

Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits.
- Practical Utility of Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop.

**PRACTICAL**

1. Extraction of Auxins from plant tissue.
2. Separation and detection of Auxins by GC/ GC-MS/ HPLC/ Immunological technique.
3. Bioassay of auxin- effect on rooting of cuttings.
4. Extraction of abscisic acid (ABA) from plant tissue.
5. Separation and detection of ABA by HPLC/ Immunological technique.
6. ABA bioassays- effect on stomatal movement.
7. Preparation of samples for ethylene estimation in plant tissue.
8. Estimation of ethylene in plant tissues using gas chromatography.
9. Ethylene bioassays, estimation using physico-chemical techniques- effect on breaking dormancy in sunflower and groundnut.
10. Extraction of Gibberellins from plant tissue- GC/ GC-MS/ HPLC.
11. Separation and detection of GA by GC/ GC-MS/ HPLC/ Immunological technique.
12. GA bioassays- effect on germination of dormant seeds.
13. Cytokinin- extraction from plant tissue.
14. Separation and detection of cytokinin by GC/ GC-MS/ HPLC.
15. Cytokinin bioassays- effect on apical dominance and senescence/ stay green

**SUGGESTED READINGS**


1. Davies, P.J. 2004, Plant Hormones: Biosynthesis, Signal Transduction and Action, 2nd Edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.
2. Hedden, P. and Thomas, S.J. 2006. Plant Hormone Signalling, Blackwell Publishing Ltd., Oxford, UK.
3. Osborne, D.J. and McManus, M.T. 2005. Hormones, Signals and Target Cells in Plant Development. Cambridge University Press, New York, USA.
4. Tucker, G.A. and Roberts, J.A. 2000. Plant Hormone Protocols. Humana Press-Springer Science, New York, USA.
5. Buchanan B B, Gruissem W & Jones R L. Biochemistry and Molecular biology of Plants, 2nd ed.
6. Lincoln Taiz and Eduardo Zeiger. Plant Physiology and Development, 6th Edition.
7. Teaching Tools in Plant Biology, The American Society of Plant Biologists.
8. The Arabidopsis Book (http://www.arabidopsisbook.org/).


## PP 521 PLANT DEVELOPMENTAL BIOLOGY: PHYSIOLOGICAL AND MOLECULAR BASIS 3(2+1)

**THEORY**

| S.No. | Blocks | Units |
|---|---|---|
| 1 | Plant Developmental Biology | 1. Evolutionary development of plants and role of environment |
| | | 2. Physiological and molecular determinants of seed biology |
| | | 3. Vegetative growth and organ development |
| | | 4. Physiological and molecular aspects of reproductive growth and development |
| | | 5. Ripening and senescence |
| | | 6. Physiological and molecular regulation of plant development influenced by light and temperature |
| 2 | Practical application of morphogenesis | 1. Tissue culture and micro-propagation |
| | | 2. Application of in-vitro techniques for crop improvement |

**BLOCK 1: PLANT DEVELOPMENTAL BIOLOGY**

**UNIT-1: Evolutionary Development of Plants and Role of Environment**

- Plant development and plasticity, evolution, Biodiversity

- Novel features of plant growth and development, Concept of plasticity-evolution and biodiversity, Model plants for study; Environment and development.
- Developmental stages and program; Cell-cycle, totipotency and regeneration.

**UNIT-2: Physiological and Molecular Determinants of Seed Biology**

- Seed development- Physiology of seed development, role of hormones in embryo development; seed development and maturation.
- Seed dormancy- Physiological and molecular mechanism of seed dormancy regulation. Seed germination- seed structure and Hormonal regulation of germination, Mobilization of food reserves during seed germination.

**UNIT-3: Vegetative Growth and Organ Development**

- Regeneration and totipotency- organ differentiation and development- role of hormones-developmental control genes in crop plants.
- Meristems in plant development.
- Shoot, Leaf, Trichome and stomate development and differentiation. Axillary shoot branching; Bud dormancy and growth
- Root development; Nodule development; Tuber development- hormonal control, signaling and molecular regulation- genes involved.
- Vascular bundle development- xylem and phloem differentiation.

**UNIT-4: Physiological and Molecular Aspects of Reproductive Growth and Development**

- Floral Induction and Development: Molecular and physiological mechanism of transition-vegetative to reproductive phase- floral organ initiation and development their controls.
- Development of male and female gametophyte; gametophytic mutants: pollen-stigma interaction- Pollen germination and tube growth; role of imprinting; Male sterility: and fertility restoration; Self incompatibility; Sterility and fertility restoration, Maternal gene effects, Zygotic gene effects.
- Sex determination in plants, mate choice in plants.
- Embryo and endosperm development- fertilization, role of imprinting; Parthenocarpy and apomixes.

**UNIT-5: Ripening and Senescence**

- Fruit development, enlargement, maturation and ripening; climacteric and non-climacteric fruit ripening mechanism.
- Hormonal, biochemical & Molecular aspects of fruit ripening
- Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

**UNIT-6: Physiological and Molecular Regulation of Plant Development Influenced by Light and Temperature**

- Light control of plant development: Phytochromes and cryptochromes, phototropins, their structure, biochemical properties and cellular distribution.
- Molecular mechanisms of light perception, signal transduction and gene regulation.
- Photoperiodism and its significance, vernalization and hormonal control.
- Circadian rhythms-biological clocks and their genetic and molecular determinants.
- Thermomorphogenesis- Thermoperiodism.

**BLOCK 2: APPLICATION OF MORPHOGENESIS AND ITS PRACTICAL APPLICATION**

**UNIT-7: Tissue culture and micro-propagation**

- Applications of tissue culture for plant production, callus induction, somatic embryogenesis, regeneration from different explants.
- Micro-propogation, tip and axillary node culture of commercially important crops, hardening and ex-vitro establishment, concept of somatic hybridization and protoplast culture.

**UNIT-8: Application of in-vitro techniques for crop improvement**

- Development of somoclones, identification and exploitation of somoclonal variants.
- Haploid production, pollen/anther, ovule/ovary culture.
- Production of secondary metabolites by tissue culture, concept of bio-fermenters.
- Plant transformation, development of transgenic plants and their characterization.
- Germplasm storage, cryopreservation and regulation.

**PRACTICAL**

1. Studying shoot apical meristem, floral meristem development and pollen tube development.
2. Phenotyping photomorphogenesis: a) Studying effect of day length (short day and long day) in regulating floral induction/ flowering time in short day/long day/day neutral plants and b) effect of light on seed germination in light-sensitive and - insensitive seeds.
3. Studying effect of temperature on- a) thermomorphogenesis- measuring hypocotyl elongation under different temperature conditions and b) sex determination using cucurbits/sesame plants.
4. Measure physiological paramters of fruit ripening and study the expression of key genes regulating ripening.
5. Study the effect of ethylene, its inhbibitor and scruber on ripening (tomato).
6. Study different sterilization techniques, prepare media stocks and plant hormones.
7. Inoculate explant (seed and leaf tissue) of model plant for callus induction.
8. Subculture the callus and standerdize regeneration protocol for shoot and root induction using callus and leaf explant.
9. Micro-propagation using meristem tip and axillary node culture.
10. Standerdize anther/ pollen culture for haploid production in model/crop/horticultural plant.
11. Isolation of protoplast from Arabidopsis/tobacco and its culturing.
12. Study about selectable marker, reporter gene, PCR, southern and northern blotting techniques.
13. Transformation of tobacco callus or leaf explant by Agrobacterium tumefacines and Agrobacterium rhizogenes for production of transgenic.
14. Molecular characterization of transgenic- PCR, southern blotting, gene expression.

**SUGGESTED READINGS**

**UNIT-1:**

1. Karl J. Niklas. Plant Evolution- An Introduction to the History of Life.
2. Bahadur *et al.* (eds.), Plant Biology and Biotechnology: Volume **I**: Plant Diversity, Organization, Function and Improvement
3. Jong and O. Leyser. Developmental Plasticity in Plants. Cold Spring Harbor Symposia on Quantitative Biology. 63-73.
4. Dirk Inze and Lieven De Veylder (2006). Cell Cycle Regulation in Plant Development. *Annu. Rev. Genet.* 2006. **40**: 77–105

**UNIT-2:**

1. J. Derek Bewley *et al.*, Seeds-Physiology of Development, Germination and Dormancy.
2. Kent J. Bradford and Hiroyuki Nonogaki (2007). Seed Development, Dormancy and Germination. Blackwell publishing.

**UNIT-3:**

3. Matthew MS Evans and M. Kathryn Barton (1997). Genetics of Angiosperm Shoot Apical Meristem Development. *Annu. Rev. Plant Physiol. Plant Mol. Biol.* **48**: 673–701.
4. Keni Jiang and Lewis J. Feldman (2005). Regulation of Root Apical Meristem Development. *Annu. Rev. Cell Dev. Biol.* **21**: 485–509.
5. Piazzaet al., (2005). Evolution of leaf developmental mechanisms. *New Phytologist.* **167**: 693-710.
6. Fiona Tooke and Nick Battey (2003). Models of shoot apical meristem function. *New Phytologist.* **159**: 37–52.
7. Zheng-Hua Ye (2002). Vascular Tissue Differentiation And Pattern Formation In Plants. *Annu. Rev. Plant Biol.* **53**:183–202.
8. Maureen L. Condic (2014). Totipotency: What It Is and What It Is Not. *Stem Cells And Development.* **23(8)**: 796- 812.

**UNIT-4**

1. Komeda, Y. 2004. Genetic regulation of time to flower in Arabidopsis thaliana. *Annu. Rev. Plant Biol.* **55**: 521-535.
2. Zeevaart, J.A.D. 1976. Physiology of flower formation. *Annu. Rev. Plant Physiol.* **27**: 321-348. Zeevaart, J.A.D. 2006. Florigen coming of age after 70 years. Plant Cell 18: 1783-1789.
3. John R. Pannel. (2017). Plant Sex Determination. *Current Biology* **27**: R191–R197.
4. Mark A. Johnson et al., 2019. A Fruitful Journey: Pollen Tube Navigation from Germination to Fertilization. *Annu. Rev. Plant Biol.* **70**: 20.1–20.29

5. JA Callow: Advances in Botanical Research- Incorporating Advances in Plant Pathology Vol. **44**, Developmental Genetics of The Flower.
6. Thomas Jack (2004). Molecular and Genetic Mechanisms of Floral Control. *The Plant Cell*. **16**: S1-17.
7. Anna M. Koltunow and UeliGrossniklaus (2003). APOMIXIS: A Developmental Perspective. *Annu. Rev. Plant Biol*. **54**:547–74.
8. Vernonica E. Franklin-Tong. Self-Incompatibility in Flowering Plants-Evolution, Diversity, and Mechanisms, Springer.

**UNIT-5:**

1. Howard Thomas (2013). Senescence, ageing and death of the whole plant. *New Phytologist*. **197**: 696–711.
2. Eric Lam, Hiroo Fukuda and Jean Greenberg. Programmed cell death in higher plants. Reprinted from *Plant Molecular Biology*, **44(3)**: 2000.
3. Eng-Chong Pua and Michael R. Davey: Plant Developmental Biology- *Biotechnological Perspectives*.

**UNIT-6:**

1. Meng Chen (2004). Light Signal Transduction In Higher Plants. *Annu. Rev. Genet*. **38**: 87–117.
2. Christian Fankhauser and Joanne Chory (1997). Light Control Of Plant Development. *Annu. Rev. Cell Dev. Biol*. **13**: 203–229.
3. Mieke de Wit (2016). Light-Mediated Hormonal Regulation of Plant Growth and Development. *Annu. Rev. Plant Biol*. **67**: 22.1–22.25
4. Keara A. Franklin and Philip A. Wigge. Temperature and Plant Development. Wiley Blackwell.
5. Keara A. Franklin et al., (2014). Interaction of light and temperature signaling. *Journal of Experimental Botany*. **65(11)**: 2859–2871.

**UNIT-7:**

1. Bhojwani SS and Razdan MK. Plant tissue culture: theory and practice, a revised edition. Elsiver publication.
2. Bhojwani SS, Sant Saran, Dantu and Prem Kumar. Plant Tissue Culture: An Introductory Text.
3. Edwin F George and Michael A Hall, E-book. Plant Propagation by Tissue Culture 3rd Edition.

**UNIT-8:**

1. Krishna, H., Alizadeh, M., Singh, D., Singh, U., Chauhan, N., Eftekhari, M., and Sadh, R. K. (2016). Somaclonal variations and their applications in horticultural crops improvement. 3 *Biotech*, **6(1)**: 54.
2. Evans, D. A. (1989). Somaclonal variation-genetic basis and breeding applications. *Trends in Genetics*, **5**: 46-50.
3. Benson, E. E., Dumet, D. J., and Harding, K. (2009). Cryopreservation of plant cells, tissues and organs. Encyclopedia of Industrial Biotechnology: *Bioprocess, Bioseparation, and Cell Technology*, 1-22.
4. Schumacher, H. M., Westphal, M., and Heine-Dobbernack, E. (2015). Cryopreservation of plant cell lines. In Cryopreservation and Freeze-Drying Protocols (pp. 423-429). Springer, New York, NY.
5. Kalaiselvi, R., Rajasekar, M., and Gomathi, S. (2017). Cryopreservation of plant materials-a review. *IJCS*, **5(5)**: 560-564.
6. Jana Murovec and BorutBohanec (2012). Haploids and doubled haploids in plant breeding. Intechopen. DOI: 10.5772/29982.
7. Maria Antonietta Germanà (2011). Anther culture for haploid and doubled haploid production. Plant Cell, Tissue and Organ Culture. Volume **104**, Issue **3**, pp 283–300.
8. Ren, J., Wu, P., Trampe, B., Tian, X., Lübberstedt, T., and Chen, S. (2017). Novel technologies in doubled haploid line development. *Plant Biotechnology Journal*, **15(11)**: 1361-1370.
9. Jim M. Dunwell, (2010). Haploids in flowering plants: Origins and exploitataion Plant Biotechnol J. 2010 May 1;8(4):377-424. doi: 10.1111/j.1467-7652.2009.00498.
10. M. R. Ferrie and K. L. Caswell (2011). Isolated microspore culture techniques and recent progress for haploid and doubled haploid plant production. Plant Cell, Tissue and Organ Culture. Volume **104**, Issue **3**, pp 301–309
11. Thijs, S., Sillen, W., Rineau, F., Weyens, N., and Vangronsveld, J. (2016). Towards an enhanced understanding of plant–microbiome interactions to improve phytoremediation:

engineering the metaorganism. *Frontiers in microbiology*, **7**: 341.

**GENERAL SOURCE INFORMATION**


1. Eng-Chong Pua and Michael R. Davey: Plant Developmental Biology - Biotechnological Perspectives.
2. B. Bahadur et al. (eds.), Plant Biology and Biotechnology: Volume **I**: Plant Diversity, Organization, Function and Improvement.
3. J. Derek Bewley et al., Seeds-Physiology of Development, Germination and Dormancy.
4. M. De Jongand O. Leyser. Developmental Plasticity in Plants. Cold Spring Harbor Symposia on Quantitative Biology. 63-73.
5. GabyongBae and Giltsu Choi (2008). Decoding of Light Signals by Plant Phytochromes and Their Interacting Proteins. *Annu. Rev. Plant Biol.* **59**:281–311
6. Viola Willemsen and Ben Scheres (2004). Mechanisms of pattern formation in plant embryogenesis. *Annu. Rev. Genet.* **38**:587–614
7. MomokoIkeuchi, *et al.*, (2016). Review- Plant regeneration: cellular origins and molecular mechanisms. *Development*, **143**: 1442-1451.
8. John R. Pannel. (2017). Plant Sex Determination. Current Biology 27, R191–R197. Vernonica E. Franklin-Tong. Self-Incompatibility in Flowering Plants -Evolution, Diversity, and Mechanisms. Springer.
9. Peter van Dijk and Jos van Damme (2000). Apomixis technology and the paradox of sex. Trends in Plant Sciences 5(2): 81-84.


## PP 522 SEED PHYSIOLOGY 3(2+1)

**THEORY**

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Physiology of Seed Development | 1. Introduction to Seed Physiology |
| | | 2. Seed Development |
| | | 3. Seed Maturation |
| | | 4. Metabolism in Developing Seed |
| 2. | Physiology of Seed Germination and Dormancy | 1. Seed Germination |
| | | 2. Seed Dormancy and Viability |

**BLOCK 1: PHYSIOLOGY OF SEED DEVELOPMENT**

**UNIT-1: Introduction to Seed Physiology**

- Importance of seed as a propagule, seed structure and functions; chemical composition of seeds. Embryogenesis: pollination and fertilization, pollen and pistil interaction, signal for interaction; pollen load hypothesis; genetical and environmental influence on seed development.
- Source-Sink relationship affecting seed yield and quality.
- Concept of seed viability and seedling vigour and their relevance; approaches to improve the storability of seeds.
- Physiological and molecular mechanisms of seed germination; approaches to improve seed germination; seed size and its influence on seed germination.

**UNIT-2: Seed Development**

- Physiology and molecular mechanisms of embryo, endosperm and seed coat development; cellularization during endosperm development; morphological and cellular changesduring seed coat development, anatomy and function of seed coat, programmed cell death (PCD) in seed coat, Deposition of seed storage reserves during development.

**UNIT-3: Seed Maturation**

- Seed maturation and maturation indices; physiological and anatomical changes during seed maturation;
- Seed drying and acquisition of desiccation tolerance in seeds; mechanisms of desiccation tolerance; role of ABA LEA's, HSP's, dehydrins and other stress proteins during seed maturation and drying,
- Seed abortion and approaches to reduce it.

**UNIT-4: Metabolism in Developing Seed**

- Chemical composition of seeds (carbohydrates, proteins, fats *etc*.), source of assimilates for seed development, pathways of movement of assimilates to developing seed, approaches to increase the chemical composition of seeds.
- Seed respiration and mitochondrial activity; seed respiration rate and storability of seeds.
- Seed ageing, Mobilization of stored resource in seeds; Chemistry of oxidation of starch, proteins and fats; Utilization of breakdown products by embryonic axis.

**BLOCK 2: PHYSIOLOGY OF SEED GERMINATION AND DORMANCY**

**UNIT-1: Seed germination**

- Seed germination, types of germination, imbibition kinetics of germinating seed; Physiological events during germination: seed respiration, mitochondrial activity, mobilization of food reserve; energy utilization by the germinating seed.
- Environmental regulation of germination: hydro-time, thermal time and hydrothermal time models; Influence of environmental factors on germination; Role of plant hormones/PGR's during seed germination**.**

**UNIT-2: Seed Dormancy and Viability**

- Physiological and molecular basis of seed dormancy, hormonal regulation of dormancy, After ripening, dormancy breaking treatments; Ecological perspective of seed dormancy.
- Seed viability: concept and physiology of seed viability, theories of seed ageing, seed storage and regulation of storage life of seeds; methods to prolong seed viability; Conservation of orthodox and recalcitrant seeds.
- Seed vigour: concept, importance, measurement; Physiological, biochemical and molecular basis of seed vigour.

**PRACTICAL**

1. Determination of seed reserves: carbohydrates, proteins and lipids;
2. Study of different seed structures;
3. Kinetics of seed imbibition; Seed germination test, enzymatic activities and respiration during germination and vigour testing methods *etc*;
4. Accelerated ageing test to know the seed vigour and storability;
5. Measurement of seed moisture content;
6. Determination of amylase activity in germinating seeds;
7. Measurement of electrical conductivity in seed leachate;
8. Measurement of seed viability using tetrazolium chloride;
9. Determination of dehydrogenase activity;
10. Seed germination study- Determination of Germination Index and seedling growth;
11. Measurement ofseed vigour index;
12. Dormancy breaking treatments;
13. Seed priming techniques;
14. Effect of environmental stresses on seed germination and seedling growth;
15. Effect of hormones on seed germination.

**SUGGESTED READINGS**


1. Bewley, J. D., Bradford K., Hilhorst H, Nonogaki H. (2013). Seeds: Physiology of Development, Germination and Dormancy, Springer-Verlag
2. Larkins, B. A and Vasil IK (Ed), Cellular and Molecular Biology of Plant Seed Development, 2010, Springer.
3. Vanangamudi, K., Natarajan, K. and Vanangamudi M, Seed Physiology, Associated Publishing Company
4. Bewley, J. D. and Black, M, 1994 Seeds: Physiology of Development and Germination, Springer.
5. Pammenter, N.W. and Patricia Berjak (2000). Aspects of recalcitrant seed physiology. R. Bras. Fisiol. Veg., 12: 56-69.
6. Prakash, M. 2011. Seed physiology of crops.(ed). Satish Serial Publishing house, New Delhi.
7. Roberto Benech-Arnold, Rodolfo Sanchez. 2004. Handbook of Seed Physiology: Applications to Agriculture. CRC Press .
8. Vijayakumar, A. 2001. Seed Dormancy an overview. In : Recent techniques and Participatory Approachs in Quality seed production (eds. K. Vanangamudiet al.,) TNAU, Coimbatore. pp

287-396.
9. Padmavathi, S., M. Prakash, S. Ezhil Kumar, G. Sathianarayanan and A.Kamaraj. 2012. A Text Book of Seed Science and Technology. New India Publishing Agency, New Delhi.
10. Tina Steinbrecher Gerhard Leubner-Metzger (2017). The biomechanics of seed germination. *Journal of Experimental Botany*, **68(4)**: 765–783.
11. Bench, A. L. R. and Sanchez, R. A. 2004. Handbook of Seed Physiology. Food Product Press.

## PP 523 PHYSIOLOGICAL AND MOLECULAR MECHANISMS OF MINERALNUTRIENT ACQUISITION AND THEIR FUNCTIONS 3 (2+1)

**THEORY**

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Mineral Nutrient: Classification, Function, Availability, Deficiency and Toxicity | 1. Mineral Elements: Classification, Function, Deficiency and Toxicity.<br>2. Nutrient Availability at Rhizosphere |
| 2. | Nutrient Uptake, Translocation and Acquisition | 1. Ion Uptake Mechanisms.<br>2. Ion Transport to Shoot and Grains.<br>3. Physiological and Molecular Mechanism of Nutrient Acquisition and Transport : Macronutrients.<br>4. Physiological and Molecular Mechanism of Nutrient Acquisition and Transport: Micro and Beneficial Nutrients.<br>5. Microbes, Fungal Association for Nutrient Acquisition.<br>6. Nutrient Delivery |
| 3 | Nutrient Efficiency of Crop | 1. Improving Nutrient Acquisition and Efficiency of Crops |

**BLOCK 1: MINERAL NUTRIENT: CLASSIFICATION, FUNCTION, AVAILABILITY, DEFICIENCY AND TOXICITY**

**UNIT-1: Mineral Elements: Classification, Function, Deficiency and Toxicity**

- Classification based on mobility and characteristic features; physiological role in regulating plant growth, metabolism, development and human health- Regulatory Dietary Allowance (RDA).
- Deficiency and toxicity of macro, micro and beneficial elements.
- Tolerance of plants to nutrient toxicity, hyper-accumulators of nutrients: Concept of phytoremediation.

**UNIT-2: Nutrient Availability at Rhizosphere**

- Biological and chemical reactions influencing nutrient availability near the root system, interaction between ions in the rhizosphere.
- Rhizosphere chemistry in relation to plant nutrition- chemical reactions, root exudates to mobilize nutrients.

**BLOCK 2: NUTRIENT UPTAKE, TRANSLOCATION AND ACQUISITION**

**UNIT-1: Ion Uptake Mechanisms**

- Mineral salt absorption- chemical potential of solute- Nernst equation- passive uptake diffusion, ion exchange-Donnan Equilibrium, mass flow of ions.
- Mediated transport- Facilitated diffusion -ionophores; membrane transport proteins-active transport-ion channels, Primary and secondary transport- carriers and pumps.

**UNIT-2: Ion Transport to Shoot and Grains**

- Long distance transport in plants - Mechanism of xylem and phloem transport, Radial movement of ions across the root.
- Mechanism of phloem transport, remobilization of mineral nutrients - phloem loading, phloem unloading.

**UNIT-3: Physiological and Molecular Mechanism of Nutrient Acquisition and Transport: Macronutrients**

- Molecular structures of LAT and HAT, their localization and regulation by various external

factors.
- Nitrate transporters and their functional regulation - Nitrate transporters (NRT1, NRT2, dual-affinity nitrate transporter NRT1.1/CHL1).
- Phosphate transporters and their functional regulation - PT1/PHT1, PHT2, PHT3, PHT4.
- Potassium transporters and their functional regulation - KT/HAK/KUP family.
- Ion transporters involved in transport of multiple elements, for example, sulphate transporter for Selenate transport, phosphate transporter for Arsenate transport, etc.

**UNIT-4: Physiological and Molecular Mechanism of Nutrient Acquisition and Transport: Micro and Beneficial Nutrients**
- Plant Strategies: Different Strategies I & II adopted by plants for uptake of Fe under Fe deficient condition.
- Transporters and genes regulating uptake and transport of micronutrients, genes encoding transport/channel proteins, Examples of genes encoding mineral ion transporters for Zn, Fe, Mn, Cu, B, Mo, Ni, Cl, Na, Si, Se.
- Beneficial nutrients and their role in plant growth and development – Sodium, Silicon, and Cobalt.

**UNIT-5: Microbes, Fungal Association for Nutrient Acquisition**
- Microbes to improve nutrient availability – Bio-inoculation technology- P solubilizers and Zinc solubilizers in nutrient absorption.
- Microbial systems for biological nitrogen fixation – process of nodulation, biochemistry of $N_2$-fixation.
- Endophytes to improve nutrient availability, Mycorrhiza- Mycorrhizal symbiosis on nutrient uptake by root. Role of AMF on nitrogen, phosphorus and zinc uptake.

**UNIT-6: Nutrient Delivery**
- Foliar application of nutrients, absorption and their compartmentation, Concept of slow release fertilizers and chelates (organic and inorganic).
- Soil less cultures- aeroponics, hydroponics, fertigation.

**BLOCK 3: NUTRIENT EFFICIENCY OF CROP**

**UNIT-1: Improving Nutrient Acquisition and Efficiency of Crops**
- Concept of nutrient uptake and use efficiency- Genotypic differences- physiology and molecular mechanisms, Nutrient use efficiency in selected crops.
- Root system architecture (RSA), root characters associated with nutrient acquisition, Genes and QTLs to improve nutrient acquisition and efficiency for important nutrients in few crop species.
- Transgenic and molecular breeding approaches to improve traits associated with acquisition and efficiency- Case studies.
- Biofortification strategies – for micronutrients, agronomic approaches
- Influence of nutrition status on plant response to biotic and abiotic stresses.

**PRACTICAL**
1. Techniques to develop the deficiency symptoms of nutrients– Hydroponics/Aeroponics- diagnosis of deficiency symptoms in agriculturally important crop plants.
2. Physiological and biochemical markers to identify nutrient deficiency levels.
3. Biochemical markers for essential elements: Assay of nitrate reductase activity for N.
4. Estimation of chlorophyll concentration in leaves of N deficient and N sufficient plants.
5. Collection of acid phosphatase from root exudates and enzyme assay for P.
6. Measuring anthocyanin and chlorophyll pigments concentration in leaves for P.
7. Collection of organic acid in root exudates, characterization and quantification for P.
8. Assay of carbonic anhydrase activity for Zn.
9. Assay of SOD Activity for Cu, Zn and Mn.
10. Estimation of nitrogen concentration in plant tissue - Kjeldhal and Dumas method.
11. Estimation of phosphorus concentration in plant tissue – colorimetric method.
12. Estimation of potassium, magnesium and sodium concentration in plant tissue - Flame Photometer.
13. Estimation of micronutrients (Zn, Cu, Fe, Mn, Co *etc*) concentration in plant tissue - atomic absorption spectrometer/ ICP-OES.
14. Measurement of simple root traits such as root length, angle, volume, surface area, *etc.* (using

conventional methods or root scanner and WinRhizo).

15. 'Shovelomics' in the field grown crops (for measuring root architecture) and using 'Image J' for analysis.
16. Non-invasive techniques to quantify nutrients – XRF (X-Ray Fluorescence) and hyper spectral reflectance.

**SUGGESTED READINGS**

**Block 1:**

**UNIT-I:**


1. Recommende Dietary Allowances:10th Edition. (https://www.ncbi.nlm.nih.gov/books/NBK234932/pdf/Bookshelf_NBK234932.pdf)
2. da Silva Lobato, A.K., Lima, E.J.A., Lobato, E.M.S.G., Maciel, G.M. and Marques, D.J., 2016. Tolerance of Plants to Toxicity Induced by Micronutrients. In Abiotic and Biotic Stress in Plants-Recent Advances and Future Perspectives. IntechOpen.
3. Renwick, A.G., 2006. Toxicology of micronutrients: adverse effects and uncertainty. The Journal of nutrition, **136(2)**: 493S-501S.
4. Krämer, U., 2018. The Plants that Suck Up Metal. German Research, **40(3)**: 18-23.
5. Orooj Surriya, S.S.S., Waqar, K. and Kazi, A.G., 2014. Phytoremediation of soils: prospects and challenges. Soil remediation and plants: *Prospects and challenges*, p.1.
6. Sarma, H., 2011. Metal hyperaccumulation in plants: a review focusing on phytoremediation technology. *Journal of Environmental Science and Technology*, **4(2)**: 118-138.


**UNIT-2:**


1. Mineral Nutrition of Higher Plants 3rdEdn– H. Marschner Plant.
2. Physiology Book by Eduardo Zeiger and Lincoln Taiz.
3. Book Chapter: Mineral Nutrition of Plants – Renu Pandey, In: Plant Biology and Biotechnology. B. Bahadur et al. (eds.), Volume I: Plant Diversity, Organization, Function and Improvement.
4. López-Arredondo, D.L., Leyva-González, M.A., Alatorre-Cobos, F. and Herrera- Estrella, L., 2013. Biotechnology of nutrient uptake and assimilation in plants. *International Journal of Developmental Biology*, **57(6-7-8)**: 595-610.


**Block 2:**

**UNIT-1:**


1. Sugita, R., Kobayashi, N.I., Hirose, A., Tanoi, K. and Nakanishi, T.M., 2019. Visualization of Ion Transport in Plants. In Agricultural Implications of the Fukushima Nuclear Accident (III) (pp. 221-231). Springer, Singapore.
2. Russell, R.S. and Clarkson, D.T., 2016. Ion transport in root systems. Perspect. *Exp. Biol*, **2**: pp.401-411.
3. Jennings, M.L., 2018. Carriers, exchangers, and cotransporters in the first 100 years of the Journal of General Physiology. The Journal of general physiology, 150(8), pp.1063-1080.
4. Aibara, I. and Miwa, K., 2014. Strategies for optimization of mineral nutrient transport in plants: multilevel regulation of nutrient-dependent dynamics of root architecture and transporter activity. *Plant and Cell Physiology*, **55(12)**: pp.2027-2036.


**UNIT-2:**


1. Barberon, M. and Geldner, N., 2014. Radial transport of nutrients: the plant root as a polarized epithelium. *Plant Physiology*, **166(2)**: pp.528-537.
2. De Schepper, V., De Swaef, T., Bauweraerts, I. and Steppe, K., 2013. Phloem transport: a review of mechanisms and controls. *Journal of Experimental Botany*, **64(16)**: pp.4839-4850.
3. Comtet, J., Jensen, K.H., Turgeon, R., Stroock, A.D. and Hosoi, A.E. 2017. Passive phloem loading and long distance transport in a synthetic tree-on-a-chip. *Nature Plants*, **3(4)**: p.17032.


**UNIT-3:**


1. Regulation of Nutrient Uptake by Plants: A Biochemical and Molecular Approach – Gyanendra Nath Mitra
2. Uraguchi, S., Kamiya, T., Sakamoto, T., Kasai, K., Sato, Y., Nagamura, Y., Yoshida, A., Kyozuka, J., Ishikawa, S. and Fujiwara, T., 2011. Low-affinity cation transporter (OsLCT1) regulates cadmium transport into rice grains. *Proceedings of the National Academy of Sciences*, **108(52)**: pp.20959-20964.
3. William C. Plaxton and Hue T. Tran (2011) Metabolic Adaptations of Phosphate-Starved

Plants. *Plant Physiology*, **156**:1006–1015.

4. Elanchezhianet al. (2015). Physiological and molecular approaches for improving phosphorus uptake efficiency of crops. *Current Science*, **108(7)**: 1271-1279.
5. O'Brien et al. (2016). Nitrate Transport, Sensing, and Responses in Plants. *Molecular Plant* 9: 837–856. doi.org/10.1016/j.molp.2016.05.004
6. Ragel, P., Raddatz, N., Leidi, E.O., Quintero, F.J. and Pardo, J.M., 2019. Regulation of K+ nutrition in plants. *Frontiers in Plant Science*, **10**.
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## PP 524 PHYSIOLOGY OF FIELD CROPS 2 (2+0)

**Broad categories of crops that can be selected for this course are as follows.**

1. Cereals – Rice, Wheat, Maize *etc.*
2. Millets – Finger millet, Sorghum, pearl millet *etc.*
3. Pulse crops- Green gram, Black gram, Lentil, Pigeon pea, Chickpeas, Cowpea, Beans *etc.*
4. Oilseed crops – Groundnut, Rapeseed Mustard, Soybean, castor *etc.*
5. Sugarcane
6. Fibre crops- Cotton, Jute, Ramie, Hemp *etc.*

**THEORY**

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Physiology of Field crop | 1.Introduction |
| | | 2. Crop Establishment, Crop Growth and Development |
| | | 3. Reproductive Growth |
| | | 4. Seed Nutrient Quality |
| | | 5. Plant Nutrition |

| | | |
|---|---|---|
| | | 6. Abiotic Stress Response |
| | | 7.Crop Specific Physiological Processes and Importance |

**BLOCK 1: PHYSIOLOGY OF MAJOR FIELD CROPS**

**UNIT-1: Introduction**
- Origin- Variability in physiology of crop plants between wild species and cultivated. Adaptability to growing environments (ecosystems), Importance in food grain contribution of major field crops.

**UNIT-2: Crop Establishment, Crop Growth and Development**
- Seed characteristic features, dormancy, viability, concept of seed priming seedling establishment and crop stand.
- Different crop growth stages, concept of source establishment and optimum LAI, Canopy architecture, light interception/radiation use efficiency, thermal time, heat units, GDD, determining growth duration.

**UNIT-3: Reproductive Growth**
- Photo and thermo-periodic response for flowering, sink development, sink source relationship, partitioning efficiency, improvement in HI, yield determining factors, genetic gain in yield over years, structuring of ideal plant type, limitations to improve source to sink size, options to improve yield potential.

**UNIT-4: Seed Nutrient Quality**
- Seed quality, seed as a source of nutrients, seed constituents and their improvement, concept of pathway engineering to improve seed quality.

**UNIT-5: Plant Nutrition**
- Nutrient requirement, genetic variability in nutrient acquisition under constraint conditions, specific nutrient disorders.

**UNIT-6: Abiotic Stress Response**
- Response to different abiotic stresses, plant traits/mechanics to improve adaptation to realize potential yields.
- Global warming responses, thermomorphogenesis, approaches to overcome the constraints.

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5. Nature's pulse power: legumes, food security and climate change. Michael J.Considine, Kadambot H.M. Siddique, and Christine H. Foyer· J Exp Bot. 2017 Apr1; 68(8): 1815-1818. Published online 2017 May 11. doi: 10.1093/jxb/erx099

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**Maize:**

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4. Von Caemmerer, S., Quick, W.P. and Furbank, R.T., 2012. The development of $C_4$ rice: current progress and future challenges. *Science*, 336(6089), pp.1671-1672.
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**Cereals and Millets:**

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**Wheat:**

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2. Kumar R, Kaur A, Ankita P, Mamrutha HM, Singh GP 2019. CRISPR based genome editing in wheat: A comprehensive review and future prospects. *Molecular Biology Reports*.
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4. Wheat Physiological Breeding II: A Field Guide to Wheat Phenotyping. (CIMMYT Publication).
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## PP 531 PHOTOSYNTHETIC PROCESSES, CROP GROWTH AND PRODUCTIVITY AND CONCEPTS OF CROP MODELING 3 (2+1)

**THEORY**

| S.No. | Blocks | Units | |
|---|---|---|---|
| 1. | Photosynthetic Processes | 1. | Canopy Architecture and Energy Utilization |
| | | 2. | Photochemical Processes |
| | | 3 | Biochemical Processes |
| | | 4. | Product Synthesis and Translocation |
| | | 5. | Growth and Yield forming Mechanisms |
| 2. | Yield Improvement and Modeling | 1. | Molecular Options to Improve Photosynthesis, Growth and Productivity |

| | | | |
|---|---|---|---|
| | | 2. | Fundamentals of Dynamic Simulation Models |
| | | 3. | Description of Well-established Yield Models |
| | | 4. | Examples of Robust Models Extensively Used |

**BLOCK 1:PHOTOSYNTHETIC PROCESSES**

**UNIT-1: Canopy Architecture and Energy Utilization**

- Parameters associated with canopy architecture that determine radiation interception and absorption.
- Energy absorption by primary and accessory pigments and energy utilization efficiency.
- Light distribution inside the canopy and concepts of light extinction coefficient.

**UNIT-2: Photochemical Processes**

- Ultrastructure of chloroplast: structure and composition of lamellar system.
- Components of electron transport, Water oxidation system and energy conservation processes.
- Pigment systems and the generation of a powerful oxidant and a powerful reductant.
- Chlorophyll fluorescence and fluorescence quenching: qN, qP, NPQ.

**UNIT-3: Biochemical Processes**

- $CO_2$ diffusion and resistances (gs and gm). Concept of Ci determining $CO_2$ diffusion.
- RuBisCO activation state, kinetics and catalytic properties.
- Carboxylation processes in $C_3$, $C_4$ and CAM plants and their relevance.
- $CO_2$ concentrating mechanisms and their importance in improving carbon assimilation.
- Ecological significance of $C_4$ and CAM photosynthesis.
- Photorespiration and Mitochondrial respiration and net carbon gain.
- Carbon isotope discrimination and its importance as a surrogate of Ci.

**UNIT-4: Product Synthesis and Translocation**

- Triose phosphate utilization and regulation of Calvin cycle mechanisms.
- Product synthesis and partitioning between starch and sucrose.
- Concepts of end-product inhibition or Pi-regeneration limitation.
- Phloem transport and factors that regulate phloem loading and un-loading.

**UNIT-5: Growth and Yield forming Mechanisms**

- Carbon gain and the concepts of Canopy photosynthesis. Relevance of LAI and LAD in determining total carbon gain and crop growth rates.
- Source: Sink relationship and its relevance in governing differences in crop growth rates and productivity.
- Concepts of HI and partitioning coefficient and remobilization of carbon from vegetative organs to reproductive structures.
- Growth analysis and parameters that explain growth rates: NAR, CGR, HI and their inter-dependence.

**BLOCK 2: YIELD IMPROVEMENT AND MODELING**

**UNIT-1: Molecular Options to Improve Photosynthesis, Growth and Productivity**

- Characteristic features of the Chloroplast genome: its structure and genes associated with various photosynthetic mechanisms, coordinated expression of chloroplast and nuclear genome for maintaining photosynthetic activities.
- Genomic and genetic resources such as specific genes and QTL associated with photosynthetic processes.
- Transgenic options to enhance photosynthetic performance such as transferring genes to mitigate oxidative stress damage (SOD, APX, AKR *etc*.).
- Theoretical concepts of crop improvement through inducing CCM in $C_3$ plants and reducing photorespiration.

**UNIT-2: Fundamentals of Dynamic Simulation Models**

- Collection of crop specific genetic coefficient.
- Crop, soil and historic weather data.

**UNIT-3: Description of Well-established Yield Models**

- Application and limitations of modeling.
- Yield prediction models such as APSYM, Peanut Grow *etc*.
- Machine learning approaches and IoT for making informed on-farm decisions.

**UNIT-4: Examples of Robust Models Extensively Used**

- Duncan's yield prediction model.
- Passioura's model for growth maximizing.

**PRACTICAL**

1. Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA portioning efficiency, HI.
2. Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized.
3. Gas exchange: Principles and uses to assess variations in $CO_2$ and water vapour transfer, determination of A/gs and intrinsic WUE.
4. Quantification of chlorophyll content by various methods: colorimetric and SPAD meter. The concept of SLN.
5. Chlorophyll fluorescence and quenching coefficients.
6. Theoretical aspects of carbon isotope fractional and its use in determining WUE.
7. Quantification of RuBisCO content by ELISA (if possible).
8. Determination of RuBisCO activity and activation state using radioactive $CO_2$.
9. $CO_2$ and light response curves and computation of carboxylation efficiency, quantum efficiency, relative limitations of photosynthesis at single leaf level.
10. Adoption of crop models: Growth and yield prediction by Duncan's and Passioura's models.

**SUGGESTED READINGS**

**Block 1:**

**UNIT-1:**

1. Goyne, P. J., Milroy, S. P., Lilley, J. M., and Hare, J. M. (1993). Radiation interception, radiation use efficiency and growth of barley cultivars. *Australian Journal of Agricultural Research*, **44(6)**: 1351-1366.
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**UNIT-2:**

1. Ruban, A. V. (2016). Nonphotochemical chlorophyll fluorescence quenching: mechanism and effectiveness in protecting plants from photodamage. *Plant Physiology*, **170(4)**: 1903-1916.
2. Maxwell, K., and Johnson, G. N. (2000). Chlorophyll fluorescence-a practical guide. *Journal of Experimental Botany*, **51(345)**: 659-668.

**UNIT-3:**

1. Wang, Y., Stessman, D. J., and Spalding, M. H. (2015). The CO2 concentrating mechanism and photosynthetic carbon assimilation in limiting CO2: how Chlamydomonas works against the gradient. *The Plant Journal,* **82(3)**: 429-448.
2. Dietz, K. J., and Pfannschmidt, T. (2011). Novel regulators in photosynthetic redox control of plant metabolism and gene expression. *Plant Physiology,* **155(4)**: 1477-1485.
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**UNIT-4:**

1. Paul, M. J., and Foyer, C. H. (2001). Sink regulation of photosynthesis. *Journal of experimental botany,* **52(360)**: 1383-1400.
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**UNIT-5:**

1. Weraduwage, S. M., Chen, J., Anozie, F. C., Morales, A., Weise, S. E., and Sharkey, T. D. (2015). The relationship between leaf area growth and biomass accumulation in Arabidopsis thaliana. *Frontiers in Plant Science,* **6**: 167.
2. Hay, R. K. M. (1995). Harvest index: a review of its use in plant breeding and crop physiology. *Annals of Applied Biology,* **126(1)**: 197-216.
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**Block 2: UNIT-1:**

1. De Freitas Lima, M., Eloy, N. B., de Siqueira, J. A. B., Inzé, D., Hemerly, A. S., and Ferreira, P. C. G. (2017). Molecular mechanisms of biomass increase in plants. *Biotechnology Research and Innovation,* **1(1)**: 14-25.

2. Raines, C. A. (2011). Increasing photosynthetic carbon assimilation in $C_3$ plants to improve crop yield: current and future strategies. *Plant physiology,* **155(1)**: 36-42.
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**UNIT-2:**

http://ijid.informaticspublishing.com/index.php/ijid/article/download/111838/78332

**UNIT-3:**

http://ijid.informaticspublishing.com/index.php/ijid/article/download/111838/78332
https://www.mdpi.com/1424-8220/18/8/2674/pdf

**UNIT-4:**

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**General Source Information:**

1. Molecular mechanisms of Photosynthesis 2nd Edition 2014 by Robert E Blankenship.
2. Canopy Photosynthesis: From Basics to Applications. 20165 Editors: Hikosaka,
3. Kouki, Niinemets, Ülo, Anten, Niels P.R. The Leaf: A Platform for Performing Photosynthesis. 2018. Editors: AdamsIII, William W., Terashima, Ichiro.
4. Handbook of Photosynthesisn 3rd Edition. 2016. Mohammad Pessarakli.


## PP 532 PHYSIOLOGY OF HORTICULTURE CROPS 2 (2+0)

**Broad categories of crops that can be selected for this course are as follows.**

1. Fruit crops: Mango, Grapes, Apple, Banana, Citrus, ber *etc.*
2. Vegetable crops: Tomato, Onion, Brinjal, Cauliflower, Okra *etc.*
3. Tuberous crops: Potato, Cassava, Sweet potato, Yam *etc.*
4. Plantation crops: Coconut, Oil palm, Cashew, Tea, Coffee, Rubber, Areca nut, Cocoa *etc.*
5. Floriculture crops: Rose, Marigold, Carnation, Chrysanthemum, Gladiolus, Orchids, Tuberose *etc.*

**THOERY**

| S.No. | Blocks | Units | |
|---|---|---|---|
| 1. | Physiology of Horticultural Crops | 1. | Introduction |
| | | 2. | Crop growth and Development |
| | | 3. | Reproductive Growth |
| | | 4. | Pre and Post-harvest Physiology |
| | | 5. | Plant Nutrition and Abiotic Stress Responses |
| | | 6. | Specific Aspects and Unique Crop Features |

**BLOCK 1: PHYSIOLOGY OF MAJOR HORTICULTURAL CROPS**

**UNIT-1: Introduction**

- Origin, distribution and adaptability of crops to different agro-climatic conditions of major horticultural crops.

**UNIT-II: Crop growth and Development**

- Internal factors (hormone *etc.*) influencing various physiological processes linked to vegetative growth or growth of specific organ, correlative and algometric growth\
- External factors (water, nutrition, temperature *etc.*) influencing various physiological processes linked to vegetative growth or growth of specific organ, correlative and algometric growth
- Propagation methods, grafting, cutting, budding, air layering. Physiology of pruning, dwarfing, branch bending, canopy management *etc*
- Physiological and biochemical aspects of scion and root stock interaction and compatibility.

**UNIT-III: Reproductive Growth**

- Physiology of flowering, photo- and thermo-periodism and response to vernalization
- Factors influencing reproductive growth, fruit and seed set/retention, physiology of flower sex ratio
- Physiological processes governing source-sink relationship and productivity**.**

**UNIT-IV: Pre and Post Harvest Physiology**

- Preharvest factors influencing postharvest physiology.
- Physiological and molecular mechanisms of ripening.
- Physiological and molecular mechanisms of senescence.
- Hormonal and chemical control of postharvest deterioration of fruits/vegetable/flowers.
- Regulation of ripening at physiological and molecular levels.
- Regulation of senescence at physiological and molecular levels.
- Approaches to improve shelf life and storability.
- Approaches to improve postharvest management.
- Approaches to improve processing and value addition.

**UNIT-V: Plant Nutrition and Abiotic Stress Responses**

- Nutrient acquisition and requirement, plant phenology and nutrient requirement Role of rootstocks in nutrient acquisition and in abiotic stress tolerance.
- Adaptive mechanisms and approaches to improve performances under drought and high temperature.
- Adaptive mechanisms and approaches to improve performances under frost, chilling and nutrient deficient conditions.
- Root physiology in abiotic stress tolerance.

**UNIT-VI: Specific Aspects and Unique Crop Features Specific aspects:**

- Polyhouse cultivation.
- Hormones/PGRs for improving crop performance.
- Major and micronutrients for improving crop performance.
- Light interception, shade regulation, dwarfing root stocks.
- Chilling requirement for flowering, photoperiodic response, pollen viability, stigma receptivity.
- Flower (blossom) and fruit drop.

**Unique Crop features:**

- Maturity and maturity indices.
- Source-sink relations.
- Vegetative propagation.
- Physiology of tuberization and rhizome initiation and formation.
- Virus free planting material.
- Bulbs/tubers dormancy, bud break.
- Physiological disorders.
- Storage.
- Packaging.
- Quality.

**SUGGESTED READINGS**

**Block 1: Books**

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2. Dhillon/Bhatt, Fruit Tree Physiology, ISBN-10: 9380428421, ISBN-13: 978-9380428420 Narendra Publishing House (2012),
3. Prerak Bhatnagar, Physiology of Growth and Development of Horticultural Crops, ISBN-10:817754666X, ISBN-13: 978-8177546668
4. Amar Singh, Fruit Physiology and Production, ISBN-10: 8127211788, ISBN-13: 978-8127211783, Kalyani Publishers; 5th edition (March 28, 2003).
5. Krishna Hare, Physiology of Fruit Production, ISBN-10:9380012373, ISBN-13:978-9380012377, Studium Press India Pvt. Ltd (2012).
6. Edward F. Durner, Principles of Horticultural Physiology, ISBN-13: 978-1780643069, ISBN-10:1780643063, CABI (June 3, 2013).
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8. Dr. Mukul Kumar, Physiology of Fruit Production, ISBN-10:9384568384, Year- 2015.
9. ElhadiM. Yahia and Armando Carrillo-Lopez, Postharvest Physiology and Biochemistry of Fruits and Vegetables, ISBN-10:0128132787, ISBN-13:978-0128132784, Woodhead Publ.
10. Sergio Tonetto de Freitas and Sunil Pareek, Postharvest Physiological Disorders in Fruits and

Vegetables, ISBN-9781138035508, ISBN-1138035505,Taylor and Francis Ltd.

**Crop Specific information:**

**Mango**

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2. Sandip, M., Makwana, A.N., Barad, A.V. and Nawade, B.D., 2015. Physiology of flowering–the case of mango. Int. J. Appl. Res, 1(11), pp.1008-1012.
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8. Hagemann, M.H., Roemer, M.G., Kofler, J., Hegele, M. and Wünsche, J.N., 2014. A new approach for analysing and interpreting data on fruit drops in mango. *Hort Science*, **49(12)**: 1498-1505.
9. Ramírez, F. and Davenport, T.L. 2010. Mango (*Mangifera indica* L.) *Flowering Physiology Scientia Horticulturae*, **126(2)**: 65-72.
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13. Lin, H.L., Shiesh, C.C. and Chen, P.J., 2012, May. Physiological disorders in relation to compositional changes in mango (Mangiferaindica L.'Chiin Hwang') fruit. In VII *International Symposium on Mineral Nutrition of Fruit Crops*, **984**: 357-363.
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**Grapes**

1. Keller, M., 2015. The science of grapevines: anatomy and physiology. Academic Press.
2. Williams, L.E., 2017. Grape. In Photoassimilate Distribution Plants and Crops Source-Sink Relationships (pp. 851-882). Routledge.
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8. Kondo, S. and Fukuda, K., 2001. Changes of jasmonates in grape berries and their possible roles in fruit development. *Scientia Horticulturae*, **91(3-4)**: 275-288.
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ripening. *Australian Journal of Grape and Wine Research*, **6(2)**: 131-135.

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**Guava**

1. Rodrigues, A.A.M., Silva, S.D.M., Dantas, A.L., Silva, A.F.D., Santos, L.D.S. and Moreira, D.D.N., 2018. Physiology and postharvest conservation of 'Paluma'guava under coatings using Jack fruit seed-based starch. *Revista Brasileira de Fruticultura*, **40(2)**.
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8. Guava Pruning and Its Physiology 2012 Shiva Adhikari.

**Tomato**

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**Onion**

1. Brewster, J.L., 2018. Physiology of crop growth and bulbing. In Onions and allied crops (pp. 53-88). CRC Press.
2. Currah, L., Cools, K. and Terry, L.A., 2012. Onions, shallots and garlic. Teoksessa: Rees, D., Farrell, G. and Orchard, J.(toim.). Crop post-harvest: Science and Technology, 3, pp.360-391.
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**Brinjal**

1. Sharma, S.P. and Brar, J.S., 2008. Nutritional requirements of brinjal (*Solanum melongena* L.)- *A review. Agric. Rev*, **29(2)**: 79-88.
2. Byari, S.H. and Al-Rabighi, S.M., 1995. Morphological and physiological responses of eggplant cultivars (*Solanum melongena* L.) to drought. J. KAU: *Met. Env, Arid Land Agric. Sci*, **6**: 414.

## PP 534 PHENOTYPING PHYSIOLOGICAL PROCESSES 2(2+0)

**THEORY**

| S. No. | Blocks | Units | |
|---|---|---|---|
| 1. | Phenotyping Physiological Processes | 1. | Concept of Phenotyping |
| | | 2. | Phenotyping for Traits for Crop Establishment |
| | | 3. | Concept and Approaches to Identify Genotypes with Superior Growth Rate |
| | | 4. | Identifying Photo-insensitive Genotypes-options and Approaches |
| | | 5. | Identifying Thermo-insensitive Genotypes-options and Approaches |
| | | 6. | Yield Structure Analysis- Relevant Yield Attributes |
| | | 7 | Source-sink Relationship- Assessment of Limitation |
| | | 8 | Identify Genetic RESOURCES for Abiotic Stress |

**BLOCK 1: PHENOTYPING PHYSIOLOGICAL PROCESSES**

**UNIT-1: Concept of Phenotyping**

- Phenotyping technologies are essential component for assessing plant responses, identify superior trait donors, mitigation responses, trait introgression and trait based breeding.

**UNIT-2: Phenotyping for Traits for Crop Establishment**

- Seed viability, seed dormancy, seed hydration rates, seed density and weight Seedling vigour in normal and adverse conditions.

**UNIT-3: Concept and Approaches to Identify Genotypes with Superior Growth Rate**

- Phenotyping for leaf expansion, leaf area index, light interception and crop extinction coefficient.
- Pigment quantification for nitrogen and chlorophyll status - SPAD, anthocyanin and flavonoids – Duolex.
- Growth rates by non-invasive techniques like NDVI, Concept of Net assimilation rate and DM/LAD; surrogates for photosynthetic traits; stomatal characteristic.

**UNIT-4: Identifying Photo-insensitive Genotypes-options and Approaches**

- Exposing to longer and shorter photoperiod by staggered sowing; extending the day length-light interception by red light; days to heading/ anthesis, approaches for synchronization of flowering.

**UNIT-5: Identifying Thermo-insensitive Genotypes-options and Approaches**

- Altering total degree days- staggered sowing at lower latitudes or by growth chambers; quantifying heading, anthesis, maturity and grain filling days, grain number and weight, grain filling rate.

**UNIT-6: Yield Structure Analysis- Relevant Yield Attributes**

- Pollen biology, stigma receptivity, spikelet sterility (cereals), floral abscission (other crops), fruiting points/ productive tillers, number of grains/ fruits per panicle/ inflorescence and grain characteristic.
- Phenotyping for lodging- culm traits, intermodal length, lignification, Phenylalanine ammonia lyase (PAL) and Tyrosine ammonia lyase (TAL).
- Approaches to identify genetic resources with traits to improve yield potential.

**UNIT-7: Source-sink Relationship- Assessment of Limitation**

- Phenotyping for source-sink size, Concept of sink-source limitation- defloration and defoliation
- Remobilization of stored metabolites and concept of stay green; estimation of water soluble carbohydrates; partitioning coefficient and harvest index.

**UNIT-8: Identify Genetic Resources for Abiotic Stress Constraints**

**Approaches for precise stress imposition to diverse stresses**

- Identify trait donor lines for different stresses: approaches by Stress Susceptibility Index (SSI), Stress Induction Response (SIR)
- Capturing variability for adaptive traits: root traits, stomatal factors/wax, osmolyte, surrogate approach for acquired tolerant traits, Flowering response, Spikelet fertility, Abscission and Senescence.
- Screening high density response-based on SSI – root adaptation and Shade Avoidance Response (SAR).

**SUGGESTED READINGS**


**UNIT-1:**

1. Kumar, J., Pratap, A., and Kumar, S. 2015. Plant Phenomics: An Overview.
2. Pratap, A., Gupta, S., Nair, R. M., Gupta, S. K. Schafleitner, R.,Basu, P. S., Singh, C. M., Prajapati, U., Gupta, A. K., Nayyar, H., Mishra, A. K.,Baek, K.-H. 2019, Using Plant Phenomics to Exploit the Gains of Genomics. *Agronomy*, **9**: 126.

**UNIT-2:**

1. AOSA. 2009. Seed Vigor Testing Handbook. Contribution No. 32 to the Handbook on Seed Testing.
2. Finch-Savage, W. E., andBassel, G. W. (2015). Seed vigour and crop establishment: extending performance beyond adaptation. *Journal of Experimental Botany*, **67(3)**: 567-591.

**UNIT-3:**

1. Muñoz-Huerta, R., Guevara-Gonzalez, R., Contreras-Medina, L., Torres-Pacheco, I., Prado-Olivarez, J., and Ocampo-Velazquez, R. (2013). A review of methods for sensing the nitrogen status in plants: advantages, disadvantages and recent advances. *Journal of Sensors*, **13(8)**: 10823-10843.
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**UNIT-4:**

1. Ouzounis, T., Rosenqvist, E., and Ottosen, C., 2015, Spectral Effects of Artificial Light on Plant Physiology and Secondary Metabolism: A Review- *American Society Horticulture Science*. **50(8)**: 1128–1135 doi.org/10.21273/HORTSCI.50.8.1128
2. The Flowering Response of the Rice Plant to Photoperiod : A Review of The Literature Fourth Edition.

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1. Sehgal, A., Sita, K., Siddique, K. H., Kumar, R., Bhogireddy, S., Varshney, R. K., andNayyar, H. (2018). Drought or/and Heat-Stress Effects on Seed Filling in Food Crops: Impacts on Functional Biochemistry, Seed Yields, and Nutritional Quality. *Frontiers in Plant Science*, **9**.
2. Prasad, P. V., Bheemanahalli, R., andJagadish, S. K. (2017). Field crops and the fear of heat stress-Opportunities, challenges and future directions. *Field Crops Research*, **200**: 114-121.

**UNIT-6:**

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2. Khobra, R., Sareen, S., Meena, B. K., Kumar, A., Tiwari, V., and Singh, G. P. (2019). Exploring the traits for lodging tolerance in wheat genotypes: A review: *Physiology and Molecular Biology of Plants*, **1**-12.
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**UNIT-7:**

1. White, A. C., Rogers, a., Rees, M and Osborne, C.P., 2016. How can we make plants grow faster? A source–sink perspective on growth rate. *Journal of Experimental Botany*, **67(1)**:31–45.
2. Ragheba, A., El-Shimyb, H andRaghebb, G., (2016). Green architecture: a concept of sustainability, Procedia - *Social and Behavioral Sciences* **216**: 778 – 787.

**UNIT-8:**

1. Wang, H., Wu, G., Zhao, B., Wang, B., Lang, Z., Zhang, C., and Wang, H. 2016, Regulatory modules controlling early shade avoidance response in maize seedlings, *BMC Genomics***17**:269.
2. Carriedo, L., Maloof, J and Brady, S., (2016). Molecular control of crop shade avoidance. *Current Opinion in Plant Biology*. **30**: 151-158. 10.1016/j.pbi.2016.03.005.


## PP 535 CROP GROWTH REGULATION AND MANAGEMENT 2(2+0)

**THEORY**

| S.No. | Blocks | Units |
|---|---|---|
| 1. | Propagation - Crop Establishment | 1. Seed as a propogule |
| | | 2. Vegetative propogule |

| | | |
|---|---|---|
| 2. | Regulation of Plant Growth Processes | 1. Regulation of plant growth and flowering |
| | | 2. Fruit ripening and its regulation |
| | | 3. Concept of senescence and its retardation |
| 3. | Protective Cultivation - Stress Mitigation | 1. Protective cultivation interventions to alter physiological processes and growth |
| | | 2. Drought mitigation options and approach |
| | | 3. Specific plant processes regulated by chemicals and growth hormones |

**BLOCK 1: PROPAGATION - CROP ESTABLISHMENT**

**UNIT-1: Seed as a Propogule**

- Concept of improving seed characteristics for crop establishment. Mechanisms of regulating seed dormancy, precocious germination, ways to control pre-harvest sprouting in crop plants.
- Seed viability and its regulation, factors to minimize loss of viability and improve seedling vigour.
- Concept of seed priming, techniques of priming, seed priming to induce tolerance to stresses.
- Role of media, nutrition and PGPR's on seedling vigour and subsequent crop establishment.

**UNIT-2: VegetativePropogule**

- Chemical and hormonal regulation of vegetative propagation.
- Regulation of rooting, bud sprouting, Bulb/tuber dormancy.
- Chemical regulation of graft union.
- Concept ofinvitromicropropogation.

**BLOCK 2: REGULATION OF PLANT GROWTH PROCESSES**

**UNIT-1: Regulation of Plant Growth and Flowering**

- Chemical and hormonal regulation of plant architecture, tillering, branching, bud breaking.
- Regulation of flowering by photo and thermoperiod, nutrients, chemicals and hormones, concept of speed breeding.
- Flowering synchrony in hybrid seed production Sex ratio alteration, flower and fruit thinning.
- Pollen viability in relation to environment, harvesting, storage and transportation.
- Prevention of abscission, flower and fruit drop, seed and fruit growth regulation- role of hormones.

**UNIT-2: Fruit Ripening and its Regulation**

- Approaches to improve shelf life – storage environment, water loss, respiration.
- Modified atmosphere, gaseous environment for storage, storage disorders, chilling injury.

**UNIT-3: Concept of Senescence and its Retardation**

- Physiology of senescence and options to regulate.
- Chemical regulation of senescence, maintenance of chlorophyll during storage, role of hormones/ micronutrients in reducing senescence.
- Concept of stay green, advantages and limitations. Relevance of stay green traits in plant breeding for crop improvement.

**BLOCK 3: PROTECTIVE CULTIVATION –STRESS MITIGATION**

**UNIT-1: Protective Cultivation Interventions to Alter Physiological Processes and Growth**

- Spectral characteristics of light in polyhouse, light regulation to optimize plant photosynthetic. and photomorphogenic processes and plant growth.
- LED sources of monochromatic light to regulate growth, etiolating and flowering.
- High temperature induced thermomorphogenic processes.
- Artificial growing media, soilless cultures, aeroponics, fogoponics.
- Concept of $CO_2$ fertilization.
- Effect of humidity on leaf expansion and growth.

**UNIT-2: Drought Mitigation Options and Approaches**

- Moisture conservation options at soil and plant level
- Concept of increasing water holding capacity, role of Hydrogels – water and mineral nutrients release pattern.
- Approaches to improve transpiration over evapo-transpiration, stomatal and non-stomatal regulation of water loss, antitranspirants.
- Osmoprotectants, ROS scavengers, plant nutrients.

- Root stocks in improving tolerance.
- Chemical regulation of flower drop due to temperature.
- Chemicals to improve pollen viability during abiotic stress.

**UNIT-3: Specific Plant Processes Regulated by Chemicals and Growth Hormones**

- Rooting of cuttings.
- Wine brewing industry.
- Promotion of gynoecious flower.
- Hybrid rice production.
- Induction of flowering in pine apple, cucurbits.
- Delaying of senescence and ripening.
- Production of dwarf plant for ornamental purpose.
- Reduction in flower and fruit drop.
- Increase in berry size in grapes.

**SUGGESTED READINGS**

**Block 1:**

**UNIT-1:**


1. Wu X, Ning F, Hu X and Wang W(2017). Genetic Modification for Improving Seed VigorIsTransitioning from Model Plantsto Crop Plants. *Frontiers in Plant Sciences*.
2. William E. Finch-Savage and Steven Footitt. Seed dormancy cycling and the regulation of dormancy mechanisms to time germination in variable field environments. *Journal of Experimental Botany*, **68(4)**: 843-856.
3. Irfan Afzal, Hafeez Ur Rehman, Muhammad Naveed and Shahzad Maqsood, Ahmed Basra. Recent Advances in Seed Enhancements. Intech. 2016.


**UNIT-2:**


1. Techniques and Experiments Plant Tissue Culture Techniques.
2. Amrit K. Nanda and Charles W. Melnyk. The role of plant hormones during grafting. *Plant Res*. 2018; **131(1)**: 49–58. Published online 2017 Nov 27.


**Block 2:**

**UNIT-1:**


1. Jorge J. Casa and Suresh kumar Balasubramanian. Thermomorphogenesis, Annual Review of Plant Biology, Vol. **70**:321-346. First published as a Review in Advance on February 20, 2019 https://doi.org/10.1146/annurev-arplant-050718-095919.
2. Abraham H Halevy Handbook of Flowering: Volume VCRC press, 2018.
3. Amy Watson, Sreya Ghosh, Lee T. Hickey Speed breeding is a powerful tool to accelerate crop research and breeding. *Nature Plants*, **4:** 23–29 (2018).


**UNIT-2:**


1. Kusumaningrum, D., Lee, S. H., Lee, W. H., Mo, C., and Cho, B. K. (2015). A review of technologies to prolong the shelf life of fresh tropical fruits in Southeast Asia. *Journal of Biosystems Engineering*, **40(4)**: 345-358.
2. Sandarani, MDJC, Dasanayaka DCMCK and Jayasinghe CVL (2018). Strategies Used to Prolong the Shelf Life of Fresh Commodities. *J Agri Sci Food Res*, **9**: 206.
3. Falagán, N and Terry, L. A. (2018). Recent advances in controlled and modified atmosphere of fresh produce. *Johnson Matthey Technology Review*, **62(1)**: 107-117.


**UNIT-3:**


1. Kim, J., Kim, J. H., Lyu, J. I., Woo, H. R., and Lim, P. O. (2017). New insights into the regulation of leaf senescence in *Arabidopsis*. *Journal of Experimental Botany*, **69(4)**: 787-799.
2. Luche, H. D. S., Silva, J. A. G. D., Maia, L. C. D., and Oliveira, A. C. D. (2015). Stay-green: a potentiality in plant breeding. *Ciência Rural*, **45(10)**: 1755-1760.


**Block 3:**

**UNIT-1:**


1. Bian, Z., Jiang, N., Grundy, S. and Lu, C., 2017, August. Uncovering LED light effects on plant growth: new angles and perspectives-LED light for improving plant growth, nutrition and energy-use efficiency. In: *International Symposium on New Technologies for Environment Control, Energy-Saving and Crop Production in Greenhouse and Plant* 1227 (pp. 491-498).
2. Barrett, G.E., Alexander, P. D., Robinson, J. S. and Bragg, N. C., 2016. Achieving environmentally sustainable growing media for soilless plant cultivation systems. A review:

*Scientia Horticulturae*, **212**: 220-234.

3. Raviv, M., Lieth, J. H. and Bar-Tal, A. eds., 2019. Soilless Culture: Theory and Practice: Theory and Practice. Elsevier.

**UNIT-2:**

1. Wang, P., Deng, Y., Li, X. Y., Wei, Z., Hu, X., Tian, F., Wu, X., Huang, Y., Ma, Y.J., Zhang, C. and Wang, Y., 2019. Dynamical effects of plastic mulch on evapotranspiration partitioning in a mulched agriculture ecosystem: Measurement with numerical modeling. *Agricultural and Forest Meteorology*, **268**:98-108.
2. Gernot Bodner, Alireza, Hans-Peter, Management of crop water under drought: A review. *Agronomy for Sustainable Development*. **2**: 401-442.

# DEPARTMENT OF MOLECULAR BIOLOGY AND BIOTECHNOLOGY
# AGRICULTURE UNIVERSITY JODHPUR

**Courses of Master's Degree Programme of Molecular Biology and Biotechnology**

| S.No. | Course Code | Course Title | Credit Hours |
|---|---|---|---|
| **Semester I** | | | |
| 1. | MBB 511 | Principles of Biotechnology | 3(2+1) |
| 2. | MBB 512* | Fundamentals of Molecular Biology | 3(2+1) |
| 3. | MBB 513* | Molecular Cell Biology | 3(2+1) |
| 4. | MBB 514 | Microbial and Industrial Biotechnology | 3(2+1) |
| 5. | MBB 515 | Environmental Biotechnology | 3(3+0) |
| 6. | MBB 516 | Introduction to Bioinformatics | 3(2+1) |
| **Semester II** | | | |
| 1. | MBB 521 | Plant Tissue culture | 3(2+1) |
| 2. | MBB 522 | Plant Genetic Engineering | 3(2+1) |
| 3. | MBB 523* | Techniques in Molecular Biology I | 3(0+3) |
| 4. | MBB 524* | Omics and Systems Biology | 3(2+1) |
| 5. | MBB 525 | Molecular Plant Breeding | 3(2+1) |
| 6. | MBB 526 | Immunology and Molecular Diagnostics | 3(3+0) |
| **Semester III** | | | |
| 1. | MBB 531 | Techniques in Molecular Biology II | 3(0+3) |
| 2. | MBB 532 | Nano Biotechnology | 3(2+1) |
| 3. | MBB 533 | Stress Biology and Genomics | 2(2+0) |
| 4. | MBB 534 | Gene Regulation | 2(2+0) |
| 5. | MBB 535 | Bio-entrepreneurship | 1(1+0) |
| 6. | MBB 536 | IPR, Bio-safety & Bioethics | 2(2+0) |
| 7. | MBB 591 | Master's Seminar | 1 |
| **Semester IV** | | | |
| 1. | MBB 598 | Comprehensive | NC |
| 2. | MBB 599 | Masters Research | (30) |

*Core courses

## COURSE CONTENTS:

**MBB 511 PRINCIPLES OF BIOTECHNOLOGY 3(2+1)**

**OBJECTIVES**

- To understand the basics of Molecular biology, plant and microbial Biotechnology
- Importance and applications in agriculture, case studies and success stories
- Public education, perception, IPR and related issues

**UNIT-I (12L)**

History, scope and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology *etc.* Basics of Biotechnology, Primary metabolic pathways, Enzymes and its activities, Plant cell and tissue culture techniques and their applications.

**UNIT-II (16L)**

Structure of DNA, RNA and protein, their physical and chemical properties. DNA function: Expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research, Plant transformation: Gene transfer methods and applications of GM crops.

**UNIT-III(8L)**

Molecular analysis of nucleic acids -PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP *etc*., and their applications; DNA sequencing, different methods; Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics.

**UNIT-IV(12L)**

Introduction to Emerging topics: Genome editing, gene silencing, Plant microbial interactions, Success stories in Biotechnology, Careers and employment in biotechnology. Public perception of biotechnology; Bio-safety and bioethical issues; Intellectual property rights in biotechnology.

**PRACTICAL**

1. Isolation of genomic and plasmid DNA;
2. Gel electrophoresis techniques;
3. Restriction enzyme digestion, ligation, theoretical demonstration of transformation and screening of transformants;
4. PCR and molecular marker analysis;
5. Plant tissue culture: media preparation, cell and explant culture, regeneration and transformation.

**SUGGESTED READINGS**

1. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M & Losick R (2014) Molecular Biology of the Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York
2. Brown, T. A. (2010) Gene Cloning and DNA analysis an Introduction 6th edition, Wiley Blackwell
3. Primrose, S. B. and Twyman, R. (2006) Principles of gene Manipulation 7th edition, Wiley Blackwell
4. Singh, B. D, Biotechnology: Expanding Horizons (2012) 4th edition, Kalyani publisher, New Delhi, India.

## MBB 512 FUNDAMENTALS OF MOLECULAR BIOLOGY 3(2+1)

**OBJECTIVES**

- To understand the basics of DNA, RNA, structure, types and chromatin assembly.
- To get insights into the Central Dogma, basic cellular processes, role of mutation and recombination.
- To understand different levels of gene regulation and the pathways involved.

**UNIT-I (8L)**

Historical developments of molecular biology, Nucleic acids as genetic material, Chemistry and Nomenclature of nucleic acids; Structure of DNA: primary structure; secondary structure, Forms of DNA: A,B,Z and their function; Structure and Types of RNA Genome organization in prokaryotes and eukaryotes; DNA Topology; DNA re-association kinetics, Types of repeat sequences.

**UNIT-II (10)**

Central dogma of Molecular Biology; DNA replication- Classical experiments, Models of DNA replication; DNA replication, Origin and Steps in DNA replication - initiation, elongation and termination; Enzymes and accessory proteins and its mechanisms; Eukaryotic DNA replication in brief. Types of DNA damages and mutations; DNA repair mechanisms, Recombination: Homologous and non-homologous, Genetic consequences.

**UNIT-III (8)**

Prokaryotic transcription, initiation, elongation and termination, promoters, Structure and function of eukaryotic RNAs and ribosomal proteins. Eukaryotic transcription – RNA polymerase I, II and III, Elongation and Termination, Eukaryotic promoters and enhancers, Transcription factors, Post transcriptional processing, Splicing: Catalytic RNAs, RNA stability and transport, RNA editing.

**UNIT-IV (10 L)**

Genetic code and its characteristics, Universal and modified genetic code and its characteristics, Wobble hypothesis; Translational machinery; Ribosomes in prokaryotes and Eukaryotes. Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes, Elongation: translocation, trans-peptidation and termination of translation; Co- and Post-translational modifications of proteins; Translational control; Protein stability-Protein turnover and degradation.

**UNIT-V (12 L)**

Gene regulation in prokaryotes, Constitutive and Inducible expression, small molecule regulators; Operon concept: lac and trp operons, attenuation, anti-termination, stringent control. Gene regulation in eukaryotes– regulatory RNA and RNA interference mechanisms, Silencers, insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix *etc*. Epigenetic regulations

**PRACTICAL**

1. Isolation of genomic and plasmid DNA;
2. Isolation of RNA;
3. Gel electrophoresis techniques;
4. Restriction enzyme digestion, ligation;
5. Theoretical demonstration of transformation and screening of transformants;
6. PCR and molecular marker analysis.

**SUGGESTED READINGS**


1. Nelson, D. L. and Cox, M. M. (2017) Lehinger's Principles of Biochemistry, 7$^{th}$ edition, W H Freeman Publication New York.
2. Krebs, J. E., Goldstein, E. S., Kilpatrick, S. T., (2017) Lewin's Genes XII 12$^{th}$ edition, Jones & Bartlett Learning publisher, Inc.
3. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M &Losick R (2014) Molecular Biology of the Gene, 7$^{th}$ edition, Cold Spring Harbor Laboratory Press, New York.
4. Alberts, B. (2017) Molecular Biology of the Cell 5$^{th}$ edition, WW Norton & Co, Inc.
5. Allison, L. A. 2011. Fundamentals of Molecular Biology. (2$^{nd}$ Edition) John Wiley and Son.


## MBB 513 MOLECULAR CELL BIOLOGY 3(2+1)

**OBJECTIVES**

- To understand the basics structure and function of plant and animal cell
- To get insights into the basic cellular processes, transport, signaling, cell movement, cell division and general regulation mechanisms.

**UNIT-I (8L)**

Origin of life, History of cell biology, Evolution of the cell: endo-symbiotic theory, tree of life, General structure and differences between prokaryotic and eukaryotic cell; Similarities and distinction between plant and animal cells; different kinds of cells in plant and animal tissues.

**UNIT-II (8L)**

Cell wall, cell membrane, structure and composition of bio-membranes, Structure and function of major organelles: Endoplasmic reticulum Ribosomes, Golgi apparatus, Mitochondria, Chloroplasts, Lysosomes, Peroxisomes, Micro-bodies, Vacuoles, Nucleus, Cyto-skeletal elements.

**UNIT-III (12L)**

Membrane transport; Diffusion, osmosis, ion channels, active transport, mechanism of protein sorting and regulation of intracellular transport, transmembrane and vesicular transport - endocytosis and exocytosis; General principles of cell communication: hormones and their receptors, signaling through G-protein coupled receptors, enzyme linked receptors; signal transduction mechanisms and regulation, Cell junctions, Cell adhesion, Cell movement; Extracellular matrix.

**UNIT-IV (10L)**

Chromatin structure, Cell division and regulation of cell cycle; Mechanisms of cell division, Molecular events at M phase, mitosis and cytokinesis, Ribosomes in relation to cell growth and division, Extracellular and intracellular Control of Cell Division; abnormal cell division: cancer-hall marks of cancer and role of oncogenes and tumor suppressor genes in cancer development - Programmed cell death (Apoptosis).

**UNIT-V (10L)**

Morphogenetic movements and the shaping of the body plan, Cell diversification, cell memory, cell determination, and the concept of positional values; Differentiated cells and the maintenance of tissues and organ development; Stem cells: types and applications; Basics of Animal development in model organisms (*C. elegans*; *Drosophila*); Plant development.

**PRACTICAL**

1. Microscopy;
2. Cell cytology and staining;
3. Structure and organization of cell and its organelles;
4. Cell division-mitosis;
5. Cell division-meiosis;
6. *In situ* hybridization, FISH technique.

**SUGGESTED READINGS**

1. Alberts, B., (2017) Molecular Biology of the Cell 5$^{th}$ edition, WW Norton & Co. Inc.
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin, K. C., (2016) Molecular Cell Biology 8th Edition. W.H. Freeman & Co. New York.
3. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Hopkin, K., Johnson, A., Walter, P., (2013) Essential of Cell Biology, WW Norton & Co,Inc.
4. Cooper, G. M. and Hausman, R. E. (2013) The cell: A Molecular Approach 6$^{th}$ edition, Sinauer Associates, Inc.

## MBB 514 MICROBIAL AND INDUSTRIAL BIOTECHNOLOGY 3(2+1)

**OBJECTIVE**

To familiarize about the various microbial processes/systems/activities, which have been used for the development of industrially important products/processes.

**UNIT-I (8L)**

Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms.

**UNIT-II (8L)**

Primary metabolites, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non-ribosomal peptide antibiotics as case study; Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry.

**UNIT-III (8L)**

Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio-transformations, Bio- augmentation with production of vitamin C as a case study; Bioreactors, their design and types; Immobilized enzymes-based bioreactors; Microencapsulation technologies for immobilization of microbial enzymes.

**UNIT-IV (8L)**

Environmental Biotechnology, bio treatment for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bio- remediation of soil; Production of eco-friendly agricultural chemicals, bio- pesticides, bio-herbicides, bio-fertilizers, bio-fuels, *etc.*

**PRACTICAL**

1. Isolation of industrially important microorganisms, their maintenance and improvement;
2. Lab scale production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery;
3. Study of bio-reactors and their operations;
4. Production of bio-fertilizers;

5. Experiments on microbial fermentation process of antibiotics, bio-pigments, dairy products, harvesting purification and recovery of end products;
6. Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomass estimation;
7. Determination of mass transfer coefficient.

**SUGGESTED READINGS**

1. Waites, M. J., Morgan, N. L., Rockey, J. S., Higton, G., (2001) Industrial Microbiology: An Introduction, Wiley-Blackwell.
2. Slater, A., Scott, N. W., & Fowler, M. R. (2003). The genetic manipulation of plants. *Plant Biotechnology Oxford, England:* Oxford University Press.
3. Kun, L. Y. (Ed.). (2003). Microbial biotechnology: principles and applications. *World Scientific Publishing Company.*

## MBB 515 ENVIRONMENTAL BIOTECHNOLOGY 3(3+0)

**OBJECTIVE**

To apprise the students about the role of biotechnology in environment management for sustainable eco- system and human welfare.

**UNIT-I (8L)**

Basic concepts and environmental issues; types of environmental pollution; problems arising from high-input agriculture; methodology of environmental management; air and water pollution and its control; waste water treatment - physical, chemical and biological processes; need for water and natural resource management.

**UNIT-II (8L)**

Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents *etc*.; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, *etc*.); anaerobic processes: digestion, filtration, *etc*.

**UNIT-III (8L)**

Renewable and non-Renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas; microbial hydrogen production; conversion of sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture *etc*.

**UNIT-IV (8L)**

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

**SUGGESTED READINGS**

1. Evans, G. Mandy Furlong, J. C. (2010). Environmental Biotechnology: *Theory and Application*. 2$^{nd}$ edition, Wiley-Blackwell.
2. Jordening, H. J.and Winter, J. (2006). Environmental Biotechnology: *Concepts and Applications*. Wiley-VCH Verlag.

## MBB 516 INTRODUCTION TO BIOINFORMATICS 3(2+1)

**OBJECTIVES**

- To get a basic overview of computational techniques related to DNA, RNA and protein analysis.
- To get a hands on training in softwares and programs used to analyze, assemble or annotate genomes, phylogenetics, proteomics *etc*.

**UNIT-I (8L)**

Bioinformatics basics, scope and importance of bioinformatics; Biological databases for DNA and Protein sequences -PIR, SWISSPROT, Gen Bank, DDBJ, secondary database, structural databases –PDB,SCOP and CATH, Specialized genomic resources, Microarray database.

**UNIT-II (10L)**

Bioinformatics Tools Facilitate the Genome-Wide Identification of Protein-Coding Genes, Sequence analysis, Sequence submission and retrieval system-SEQUIN, BANKit, SAKURA, Webin, Sequence alignment, pairwise alignment techniques, multiple sequence alignment; Tools for Sequence alignment- BLAST and its variants; Phylogenetic analysis- CLUSTAL X, CLUSTAL W, Phylip, Tcoffee.

**UNIT-III (10L)**

Sequencing of protein; Protein secondary structure prediction- Chousfasman, GOR Method, Protein 3D Structure Prediction: Evaluation of models- Structure validation and refinement - Ramachandran plot, Force field calculations, SAVES. Protein function prediction- sequence and domain based, Primer designing- principles and methods. Drug discovery**,** Structure Based Drug Design- Rationale for computer aided drug designing, basic principles, docking, QSAR.

**PRACTICAL (12L)**

1. Usage of NCBI resources;
2. Retrieval of sequence/structure from databases and submission;
3. Different Databases, BLAST exercises;
4. Assembly of DNA and RNA Seqdata;
5. Annotation of assembled sequences, Phylogenetics and alignment;
6. Visualization of structures, Docking of ligand receptors;
7. Protein structure analysis and dmodeling.

**SUGGESTED READINGS**


1. Attwood, T. K., and Parry-Smith, D. J. (2004) Introduction to Bioinformatics, Pearson Education (Singapore) Pvt. Ltd.
2. David Edwards (Ed.) (2007) Plant Bioinformatics: Methods and Protocols. Humana Press, New Jersey, USA.
3. Mount, D. W. (2004) Bioinformatics: Sequence and Genome Analysis 2nd Revised edition Cold Spring Harbor Laboratory Press, U.S.
4. Jonathan Pevsner (2009) Bioinformatics and Functional Genomics, 2nd edition, Wiley-Blackwell.


| MBB 521 | PLANT TISSUE CULTURE | 3(2+1) |
|---|---|---|

**OBJECTIVES**

- To provide insight into principles of plant cell culture and genetic transformation.
- To get a hands on training in basic plant tissue culture techniques, callusing, micropropagation and analysis.

**UNIT-I (12L)**

History of plant tissue culture, principle of Totipotency; Tissue culture media; Plant hormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of plant tissue culture; National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods – PCR,ELISA

**UNIT-II (12L)**

Micropropagation of field and ornamental crops; Virus elimination by meristem culture, meristem tip culture and micrografting; Androgenesis and gynogenesis - production of androgenic and gynogenic haploids - diploidization; Protoplast culture - isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybridization - Production of Somatic hybrids and Cybrids; Wide hybridization - embryo culture and embryo rescue techniques; Ovule, ovary culture and endosperm culture.

**UNIT-III (12L)**

Large-scalecell suspension culture - Production of alkaloids and other secondary metabolites- techniques to enhance secondary metabolite production, Somaclonal and gametoclonal variations – causes and applications; Callus culture and in vitro screening for stress tolerance; Artificial seeds, In vitro germplasm storage and cryo-preservation. Commercial Tissue Culture: Case studies and success stories, Market assessment; project planning and preparation, economics, government policies

**PRACTICAL (12)**

1. Preparation of stocks - macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium;
2. Micro-propagation of plants by nodal and shoot tipculture;
3. Embryo culture to overcome incompatibility, Anther culture for haploid production;
4. Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis;
5. Acclimatization of tissue culture plants and establishment in greenhouse;
6. Virus indexing in tissue culture plants. (Using PCR and ELISA);
7. Plan of a commercial tissue culture unit.

**SUGGESTED READINGS**

1. Razdan, M.K. (2003) Introduction to plant tissue culture, 2nd edition, Oxford publications.
2. Butenko, R. G. (2000)Plant Cell Culture University Press of Pacific.
3. Herman, E. B., (2008) Media and Techniques for Growth, Regeneration and Storage, Agritech Publications, New York, USA.
4. Bhojwani, S.S and Dantu, P. 2013. Plant Tissue Culture – An Introductory Text. Springer. Publications.
5. Gamborg, O.L and G.C.Philips (eds.). 2013. Plant Cell, Tissue and Organ culture-Lab Manual. Springer Science & Business media.

## MBB 522 PLANT GENETIC ENGINEERING 3(2+1)

**OBJECTIVES**

- To get a basic overview of molecular cloning, vectors and genomic library construction.
- To get an overview of PCR and its applications, sequencing, gene knockouts, transgenics *etc.*

**UNIT-I (10L)**

Historical background, Restriction Enzymes; DNA Modifying enzymes, ligase, $T_4$ DNA polymerase, Polynucleotide kinase *etc.*, Cohesive and blunt end ligation; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immuno-precipitation; DNA-Protein Interactions: Electromobility shift assay.

**UNIT-II (14L)**

Plasmids; Bacteriophages; M13,Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; Expression vectors; pMal, pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag *etc.*; Baculovirus vectors system, Plant based vectors, Ti and Ri plasmids as vectors, Yeast vectors, Shuttle vectors. Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning, Jumping and hopping libraries, Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression; Codon optimization for heterologous expression. Introduction of DNA into mammalian cells; Transfection techniques

**UNIT-III (12L)**

Principles of PCR, Primer designing, DNApolymerases, Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T- vectors; Applications of PCR in gene recombination, Site specific mutagenesis, in molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay.

**UNIT-IV (12L)**

Genetic transformation of plants: DNA delivery – Agrobacterium mediated method. Direct DNA delivery – chemical mediated electroporation and particle bombardment. Vectors and transgene design - Promoters and Marker genes. Chloroplast transformation. Development of marker-free plants. Analysis of transgenic plants – molecular and Biochemical assays, genetic analysis - Identification of gene integration site - Advance methods – cisgenesis, intragenesis and targeted genome modification – ZFN, TALENS and CRISPR. Application of transgenic technology.

**PRACTICAL**

1. Isolation of genomic and plasmid DNA;
2. Gel electrophoresis techniques;
3. Restriction enzyme digestion, ligation;
4. Demonstration of transformation and screening of transformants;
5. PCR techniques and primer designing;
6. Blotting techniques.

**SUGGESTED READINGS**

1. Brown, T. A. (2010) Gene Cloning and DNA analysis an Introduction 6th edition, Wiley Blackwel.
2. Primrose, S. B. and Twyman, R. (2006) Principles of gene Manipulation 7th edition, Wiley Blackwell.
3. Sambrook, J., and Russell, R.W. (2001) Molecular cloning: A laboratory manual3rd Edition, Cold spring harbor laboratory press, cold spring harbor, NewYork.
4. Wilson, K., and Walker, J., (2018) Principles and Techniques of Biochemistry and Molecular Biology 8th Edition, Cambridge University Press.

## MBB 523 TECHNIQUES IN MOLECULAR BIOLOGY I 3(0+3)

**OBJECTIVES**

- To get a basic overview of molecular biology techniques, good lab practices and recombinant DNA technology.
- To get a hands on training in chromatography, protein analysis, nucleic acid analysis, bacterial and phage genetics.

**TOPICS FOR CONDUCTING WET LAB EXERCISES**

1. Good lab practices, preparation of buffers and reagents;
2. Principle of centrifugation and spectrophotometry;
3. Growth of bacterial culture and preparation of growth curve, Isolation of Genomic DNA from bacteria;
4. Isolation of plasmid DNA from bacteria;
5. Growth of lambda phage and isolation of phage DNA;
6. Isolation and restriction of plant DNA (e.g. Rice / Mungbean / Mango /Merigold);
7. Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry
8. PCR using isolated DNA;
9. PAGEG gel elelectrophoresis;
10. Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNA construction;
11. Transformation of E. coli and selection of transformants;
12. Chromatographic techniques.
    a. TLC
    b. Gel Filtration Chromatography,
    c. Ion exchange Chromatography,
    d. Affinity Chromatography
13. Dot blot analysis, Southern hybridization, Northern hybridization;

14. Western blotting and ELISA;
15. Radiation safety and non-radio isotopic procedure.

**SUGGESTED READINGS**

1. Sambrook, J., and Russell, R.W (2001) Molecular cloning: A laboratory manual 3rd Edition, Cold spring harbor laboratory press, cold spring harbor, NewYork.
2. Wilson,K.,andWalker,J.,(2018)Principles and Techniques of Biochemistry and Molecular Biology 8th edition, Cambridge University Press.
3. Ausubel, F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A., & Struhl, K., (2002) Short Protocols in Molecular Biology 5th edition, Current Protocols publication.

| MBB 524 | OMICS AND SYSTEMS BIOLOGY | 3(2+1) |
|---|---|---|

**OBJECTIVES**

- To get a basic overview of genomics, proteomics, ionomics and metabolomics
- To get a primary information on the application of omics science across the industry

**UNIT-I (8L)**

Different methods of genome sequencing, principles of various sequencing chemistries, physical and genetic maps, Comparative and evolutionary genomics, Organelle genomics, applications in phylogenetics, case studies of completed genomes, preliminary genome data analysis, basics of ionomics analysis, different methods

**UNIT-II (6L)**

Protein-basics: primary-, secondary- and tertiary structure, Basics of X-ray crystallography and NMR, Principal and Applications of mass spectrometry, Proteomics: Gel based and gel free, Basics of software used in proteomics, MASCOT, PD-Quest *etc.*, Study of protein interactions, Prokaryotic and yeast-based expression system and purification

**UNIT-1II (6L)**

Metabolomics and its applications, Use of 1D/2D NMR and MS in metabolome analysis, Multivariate analysis and identification of metabolite as biomarkers, Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), *x*-Ray Fluorescence (XRF), Neutron activation analysis (NAA), Data integration using genome, transcriptome, proteome, metabolome and ionome with phenome.

**UNIT-IV(6L)**

Introductory systems Biology - The biochemical models, genetic models and systems model, Molecules to Pathway, Equilibrium binding and cooperatively - ichaelis-MentenKinetics, Biological oscillators, Genetic oscillators, Quorum Sensing, Cell-cell communication, Drosophila Development , Pathways to Network ,Gene regulation at a single cell level, transcription network, REGULATORY CIRCUITS, Negative and positive auto-regulation,, Alternative Stable States, Bimodal Switches, Network building and analysis

**PRACTICAL (12 P)**

1. Isolation of HMW DNA and brief overview of sequencing, Primary information on genome data analysis;
2. BSA Standard curve preparation, Extraction of protein and estimation methods;
3. Quantification of proteins from different plant tissues using spectrophotometry;
4. 2-D Gel Electrophoresis, 2-D Image analysis;
5. Experiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitin system);
6. Demonstration on MALDI-TOF;
7. Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods.

**TEXT/REFERENCES**

1. Primrose, S. B. and Twyman, R. (2006) Principles of gene Manipulation 7th edition, Wiley Blackwell
2. Wilson, K., and Walker, J., (2018) Principles and Techniques of Biochemistry and Molecular Biology 8th Edition, Cambridge University Press.

## MBB 525 MOLECULAR PLANT BREEDING 3(2+1)

**OBJECTIVE**

- To familiarize the students about the use of molecular biology tools in plant breeding.
- To provide a hands on training in data analysis, diversity analysis and mapping of genes and QTLs.

**UNIT-I (8L)**

Inheritance of qualitative and quantitative traits. Heritability – its estimation, Population structure of self- and cross-pollinated species, Factors affecting selection efficiency. Development of different kinds of segregating populations – $F_2$, $F_3$, $BC_1F_1$, $BC_1F_2$, $BC_4F_2$, RIL (Recombinant Inbred Lines), AIL (Advanced Intercrossed Lines), DH (Di-haploid population), NIL (Near Isogenic lines), NAM (Nested Association Mapping), MAGIC (Multi-parent Advanced Generation Intercross population).

**UNIT-II (8L)**

Causes of sequence variation and its types, Types of molecular markers and development of sequence based molecular markers – RFLP, AFLP, SCARs, CAPS, SSRs, STMS, SNPsInDel and DARTseq; Inheritance of markers, Linkage analysis using test cross, $F_2$, $F_3$, $BC_1F_1$, RIL. Construction of genetic map, Mapping genes for qualitative traits; Genotyping by sequencing and high-density chip arrays.

**UNIT-III (8L)**

QTL mapping using structured populations; Association mapping using unstructured populations; Genome Wide Association Studies (GWAS), Principle of Association mapping– GWAS-SNP genotyping methods, DART array sequencing, Illumina's Golden Gate Technology, Genotyping by sequencing methods- Fluidigm; GBS, Illumina Hi seq-Nano pore sequencing, Principles and methods of Genomic Selection, Fine mapping of genes/QTL; Development of gene based markers; Allele mining by TILLING and Eco-TILLING.

**UNIT-IV (8L)**

Tagging and mapping of genes. Bulk segregant and co-segregation analysis, Marker assisted selection (MAS); Linked, unlinked, recombinant, flanking, peak markers. Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples. Haplotype concept and Haplotype-based breeding; Genetic variability and DNA fingerprinting. Molecular markers in Plant variety protection, IPR issues, hybrid purity testing, clonal fidelity testing and transgenic testing.

**PRACTICAL**

1. Construction of linkage map;
2. QTL analysis using the QTL cartographer and other software;
3. SNP data analysis using TASEEL;
4. Detection of haplotype block using SNP data – pLink software;
5. Genotyping by sequencing methods –Illumina genotyping platform;
6. Marker assisted breeding – MABB case studies quality traits in rice/maize;
7. Genome Assisted Breeding in model crops, Genomic Selection models using the morphological and SNP data.

**SUGGESTED READINGS**

1. Acquaah, G., (2007) Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd. USA.
2. Weising, K., Nybom, H., Wolff, K., and Kahl, G., (2005) DNA Fingerprinting in Plants: Principles, Methods and Applications, 2nd ed. Taylor and Francis Group, Boca Raton, FL.
3. Halford, N., (2006). Plant Biotechnology-Current and future applications of genetically modified crops, John Wiley and Sons, England.
4. Singh, B. D. and Singh, A. K. (2015). Marker-Assisted Plant Breeding: Principles and Practices Springer (India) Pvt. Ltd.
5. Boopathi, NM. 2013. Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits. Springer India. p293.

## MBB 526 IMMUNOLOGY AND MOLECULAR DIAGNOSTICS 3(3+0)

**THEORY**

**UNIT-I (6L)**

Immunity and its classification; Components of innate and acquired immunity; Lymphatic system; Hematopoiesis; Organs and cells of the immune system- primary, secondary and tertiary lymphoid organs Descriptions of Antigens - immunogens, hapten and adjuvants.

**UNIT-II (12L)**

Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Basis of self and nonself discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cluster of Differentiations (CDs),Cytokines-properties, receptors and therapeutic uses;

**UNIT-III(8L)**

Phagocytosis; Complement and Inflammatory responses; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing; Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten-carrier system

**UNIT-IV(10L)**

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques-RIA, ELISA, Western blotting, ELISPOT assay, immune-fluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosenor assays for assessing ligand–receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, Transgenic mice, Gene knock outs.

**UNIT-V (12L)**

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies, Immunity to Infection, Bacteria, viral, fungal and parasitic infections , Hypersensitivity– Type I-IV; Autoimmunity; Types of autoimmune diseases, MHC and TCR in autoimmunity; Transplantation, Immunological basis of graft rejection, immunosuppressive therapy; Tumor immunology – Tumor antigens.

**TEXTS/REFERENCES**


1. Owen, J.A., Punt, J. & Stranford, S.A. (2013). Kuby immunology (p.692). New York: WH Freeman.
2. Kenneth, M., and Weaver, C., (2017), Janeways Immunobiology, 9th edition, New York, USA: Garland Science, Taylor & Francis publisher.
3. William, P., (2013), Fundamental of Immunology, 7th edition, Lippencott, William and Wilkins.


## MBB 531 TECHNIQUES IN MOLECULAR BIOLOGY II 3(0+3)

**OBJECTIVES**

- To get a basic overview of molecular biology techniques, good lab practices and molecular markers.
- To get a hands on training in RNAi, microarrays, yeast 2 hybrid and immunological techniques.

**TOPICS FOR CONDUCTING WET LAB EXERCISES**

**Construction of gene libraries (cDNA and Genomic).**

1. Synthesis and cloning of cDNA;
2. Real Time PCR and interpretation of data;
3. Molecular markers
   a) RAPD b) SSR c) AFLP / ISSR and their analysis.

4. Case study of SSR markers - construction of linkage map;
5. QTL analysis using genotypic data based on SSR;
6. SNP identification and analysis;
7. Microarray studies and use of relevant software;
   a) Proteomics – (a) 2D gels (b) Mass spectrometry
8. RNAi - designing of construct, phenotyping of the plant;
9. Yeast 1 and 2-hybrid interaction;
10. Generation and screening of mutants;
11. Transposon mediated mutagenesis;
12. Immunology and molecular diagnostics: Ouchterlony double diffusion, Immuno-precipitation, Radiation Immunodiffusion, Immuno-electrophoretic, Rocket Immuno-electrophoretic, Counter Current Immunoelectrophoretic, ELISA, Latex Agglutination, Immunohistochemistry.

**SUGGESTED READINGS**


1. Wilson, K., and Walker, J., (2018) Principles and Techniques of Biochemistry and Molecular Biology 8th Edition, Cambridge University Press
2. Bonifacino, J. S., Dasso, M., Harford, J. B., Liipincott-Schwartz, J., and Yamada, K. M., (2004), Short Protocols in Cell Biology. John Wiley & Sons, New Jersey
3. Hawes, C., and Satiat-Jeunemaitre, B., (2001), Plant Cell Biology: Practical Approach. Oxford University Press, Oxford
4. Sawhney, S. K., Singh, R., (2014) Introductory Practical Biochemistry, Alpha science international limited.


| MBB 532 | NANO BIOTECHNOLOGY | 3 (2+1) |
|---|---|---|

**OBJECTIVE**

Understanding the molecular techniques involved in structure and functions of nano-biomolecules in cells such as DNA, RNA and proteins.

**THEORY**

**UNITI (8L)**

Introduction to Nanotechnology - Nanomaterials - Self-assembly to artificial assembly for creation of useful nanostructures – Bottoms up and Top down approach (Nano rods, nano cages, nanotubes, quantum dots, nanowires, metal / polymer-based nanostructures) – Preparation and Characterization of nanoparticles (particle size analyzer, microscopy *viz.*, electron microscopy, atomic force microscopy *etc*.).

**UNIT-II (8L)**

Cell structure – Bio macromolecules: Types, structure, dynamics and interaction with water – Cellular nano machines – cellular transducers, membrane channels, membrane transporters, Membrane motors – creation of bio-nanostructures (Nano liposomes, Nano micelles, Nanomotors *etc*.).

**UNIT-III (8L)**

Chemical, physical and biological properties of biomaterials and bio response: biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems

**UNIT-IV (8L)**

Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Micro fabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

**PRACTICAL**

1. Isolation of enzymes and nucleic acids involved in biosynthesis of nanomaterials;
2. Synthesis of Gold/silver Nanoparticles by biogenic methods, Synthesis of micelles and inverse micelles;
3. Synthesis of Carbon Nano-materials by Chemical Vapour Deposition and Sputtering

technique;
4. Preparation of thiolate silver nanoparticles, Purification and measurement of carbon nano materials;
5. Zinc selenide quantum dot preparation, Synthesis of Iron Oxide Nanoparticle;
6. Thin film preparation by spin coating technique, Synthesis of Nickel metal nanoparticle by urea decomposition method;
7. Synthesis of Zinc Oxide nanoparticle.

**SUGGESTED READINGS**


1. Nalwa, H. S. 2005. Handbook of Nanostructured Biomaterials and Their Applications in Nano biotechnology. American Scientific Publications.
2. Niemeyer CM & Mirkin CA. Eds (2005). Nano biotechnology: Concepts Applications and Perspectives, Wiley Inter-science publications.
3. Cao, G., and Wang, Y., (2004) Nanostructures and Nanomaterials: Synthesis, properties and applications, Imperial College Press.


| MBB 533 | STRESS BIOLOGY AND GENOMICS | 2 (2+0) |
|---|---|---|

**OBJECTIVE**

To provide advanced knowledge on genomics with reference to abiotic stress tolerance and biotic stress resistance in plants tolerance.

**UNIT-I (10L)**

Different kinds of stresses (biotic and abiotic) and adaptation strategies: Plant cell as a sensor of environmental changes; role of cell membranes in signal perception; Ways of signal transduction in cells and whole plants as a response to external factors. Abiotic stresses affecting plant productivity – Drought, salinity, water logging, temperature stresses, light stress and nutrient stress; Drought stress – Effects on plant growth and development; Components of drought resistance; Physiological, biochemical and molecular basis of tolerance mechanisms; Biotic stress (insect and pathogen) resistance mechanism.

**UNIT-II (12L)**

Strategies to manipulate drought tolerance– Osmotic adjustment and Osmoprotectants- synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants; hormonal metabolism-ABA signaling; signaling components– transcription factors. Water logging stress– effects on plant growth and metabolism; adaptation to water logging, tolerance mechanisms-hormones and flooding tolerance. Strategies for improving submergence tolerance. Salinity stress– effects on physiology and metabolism of plants, SOS pathways and ion homeostasis, Strategies to improve salinity tolerance in plants. Water logging stress – effects on plant growth and metabolism; tolerance mechanisms. Physiological and biochemical changes– High & Low temperature tolerance mechanisms- molecular basis of thermo tolerance. Morphological and physiological changes in plants due to high and low light stresses - photo oxidation -plastid development. Characters of heliophytes and sciophytes– solar tracking– sieve effect and light channeling. Heavy metal stress– Al and Cd stress - effects on plant growth and development, biotech Strategies to overcome heavy metal stress nutrient stress- effects on plant growth and development. Genetic manipulation strategies to overcome the stress effects.

**UNIT-III (10L)**

Genomics; transcriptomes, small RNAs and epigenomes; functional genomics; transfer of tolerance/resistant genes to model plants and validation of gene function. Different techniques for the functional validation of genes. Signaling pathway related to defense gene expression, R proteins, RNAi approach and genes from pathogens and other sources, coat protein genes, detoxification genes, transgenic and disease management. Bt proteins, resistance management strategies in transgenic crops, ecological impact of field release of transgenic crops. Bioinformatics approaches to determine gene function and network in model plants under stress.

**SUGGESTED READING**


1. Buchanan, B. B., Gruissem, W. and Jones R, (2015) Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley and Blackwell Publications.

2. Sarwat, M., Ahmad, A., Abdin, M.Z. (2013) Stress Signaling in Plants: Genomics and Proteomics Perspective, Volume **1**, Springer.
3. HeribertHirt, (2010) Plant Stress Biology: From Genomics to Systems Biology, John Wiley.
4. Pandey, G. K., Elucidation of Abiotic Stress Signaling in Plants, Wiley.

## MBB 534 GENE REGULATION 2 (2+0)

**OBJECTIVE**

To understand the basics of gene regulation including a wide range of mechanisms that are used by organisms to increase or decrease the production of specific gene products in terms of time, space, conditions or their combinations.

**UNIT-I (8L)**

Transcriptional regulation – Regulatory proteins, Activators and Repressors, Binding of RNA polymerase, Allosteric regulation, DNA looping, Cooperative binding, Anti-termination, Combinatorial control – Regulation of lac, trpandara Operons. Gene regulation in Lambda phage – lytic or lysogenic establishment.

**UNIT-II (10L)**

Regulatory sequences – Promoters, Enhancers, Silencers, Insulators, Locus Control Region. Activator proteins and their binding sites, DNA binding domain – Homeodomain, Zinc containing proteins, Leucine Zipper Motif, Helix-Loop-Helix, HMG proteins. Recruitment of RNA polymerase to promoter region, Nucleosomes and their modifiers. Signal integration. Signal transduction and transcriptional regulation. Gene Silencing. Epigenetic gene regulation.

**UNIT-III (10L)**

Regulation by RNA in prokaryotes and eukaryotes, RNA as defense agents. Ribo-switches. Gene Silencing by RNA – siRNA & miRNA – synthesis and function. Non-coding RNAs their impact, categories and role in gene regulation, chromatin assembly *etc*.

**UNIT-IV (4L)**

Negative auto-regulation, Positive auto-regulation, Bistable and Bimodal switch, Oscillating pattern of gene expression.

**SUGGESTED READINGS**

1. Nelson, D. L. and Cox, M. M. (2017) Lehinger's Principles of Biochemistry, 7th edition, W H Freeman Publication New York
2. Krebs, J. E., Goldstein, E. S., Kilpatrick, S. T., (2017) Lewin's Genes XII 12th edition, Jones & Bartlett Learning publisher, Inc.
3. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Lonick, R., (2014) Molecular Biology of the Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York.
4. Gardner, E. J., Simmons, M. J. & Snustad, D. P. (2006). Principles of Genetics (2006) eighth Edition. Wiley.

## MBB 535 BIO-ENTREPRENEURSHIP 1 (1+0)

**OBJECTIVES**

The objective of this course is to teach students about fundamentals of entrepreneurship, launching a venture or a start up in biotechnology-based theme.

**UNIT-I (4L)**

Scope in biotechnology; types of bio-industries – bio-pharma, bio-agri, bio-services and bio-industrial; Importance of entrepreneurship; introduction to bio entrepreneurship – biotechnology in a global scale;–skills for successful entrepreneur–creativity, leadership, managerial, team building, decision making; opportunities for bio-entrepreneurship- entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India)

**UNIT-II (4L)**

Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/support from various agencies; statutory and legal requirements for starting a company/venture.

**UNIT-III (4L)**

Entry and exit strategy; identifying needs of customers; Market linkages, branding issues; developing distribution channels - franchising; policies, promotion, advertising; branding and market linkages for 'virtual startup company'. Pricing strategy.

**UNIT-IV (4L)**

Knowledge centers e.g., in universities, innovation centres, research institutions (public & private) and business incubators; R&D for technology development and upgradation; assessment of technology development; managing technology transfer.

**SUGGESTED READING**


1. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion.
2. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., & Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
4. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
5. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.


## MBB 536 IPR, BIO-SAFETY & BIOETHICS 2(2+0)

**OBJECTIVE**

- To familiarize the students about ethical and biosafety issues in plant biotechnology.
- To provide a hands-on training in data analysis, diversity analysis and mapping of genes and QTLs.

**UNIT-I (10L)**

IPR: historical background in India; trade secret; patent, trademark, design& licensing; procedure for patent application in India; Patent Cooperation Treaty (PCT); Examples of patents in biotechnology-Case studies in India and abroad; copyright and PVP; Implications of IPR on the commercialization of biotechnology products, ecological implications; Trade agreements- The WTO and other international agreements, and Cross border movement of germplasms.

**UNIT-II (8L)**

Biosafety and bio-hazards; General principles for the laboratory and environmental bio-safety; Biosafety and risk assessment issues; handling and disposal of bio-hazards; Approved regulatory laboratory practice and principles, The Cartagena Protocol on biosafety; Biosafety regulations in India; national Biosafety Policy and Law; Regulations and Guidelines related to Biosafety in other countries

**UNIT-III (8L)**

Potential concerns of transgenic plants - Environmental safety and food and feed safety. Principles of safety assessment of Transgenic plants - sequential steps in risk assessment. Concepts of familiarity and substantial equivalence. Risk - Environmental risk assessment - invasiveness, weediness, gene flow, horizontal gene transfer, impact on non-target organisms; food and feed safety assessment - toxicity and allergenicity. Monitoring strategies and methods for detecting transgenics.

**UNIT-IV (6L)**

Field trials – Biosafety research trials – standard operating procedures, labeling of GM food and crop, Bio-ethics-Mankind and religion, social, spiritual & environmental ethics; Ethics in Biotechnology, labeling of GM food and crop; Biopiracy.

**SUGGESTED READINGS**


1. Goel, D., and Parashar, S., (2013) IPR, biosafety, and bioethics.
2. Joshi, R., (2006) Biosafety and Bioethics.
3. Nambisan, P., (2017) An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology.

# DEPARTMENT OF NEMATOLOGY
# AGRICULTURE UNIVERSITY JODHPUR

### Semester Wise Major Courses: M.Sc. (Agri.) Nematology

| Course No. | Course No. | Course Title | Credit hours |
|---|---|---|---|
| **Semester I** | | | |
| NEMA 501* | NEMAT 511* | Principles of Nematology | 3(2+1) |
| NEMA 505* | NEMAT 512* | Nematological Techniques | 3(1+2) |
| NEMA 503* | NEMAT 513* | Structural Organization of Nematodes | 3(2+1) |
| **Semester II** | | | |
| NEMA 504* | NEMAT 521* | Nematode Systematics | 3(2+1) |
| NEMA 506* | NEMAT 522 | Nematode Diseases of Crops | 3(2+1) |
| NEMA 508 | NEMAT 523 | Nematode Ecology | 3(2+1) |
| **Semester III** | | | |
| NEMA 507 | NEMAT 531 | Nematode Biology and Physiology | 3(2+1) |
| NEMA 509 | NEMAT 532 | Nematode Interactions With Other Organisms | 3(2+1) |
| NEMA 510* | NEMAT 533 | Nematode Management | 3(2+1) |
| NEMA 591 | NEMAT 591 | Master's Seminar | 1(1+0) |
| **Semester IV** | | | |
| | NEMAT 598 | Comprensive Examinations | NC |
| NEMA 599 | NEMAT 599 | Master's Research | (30) |

Note: Course with Credit load also for Supporting courses of M.Sc./ Ph. D. degree programme
*Indicates Core Courses which are Compulsory for Master Programme, NC = Non- Credit

## COURSE CONTENTS:

**NEMAT 511 — PRINCIPLES OF NEMATOLOGY — 3 (2+1)**

**OBJECTIVE**

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology**.**

**COURSE OUTCOME**: After completition of course student will have experience on the knowledge of plant parasitic nematodes.

**THEORY**

**UNIT-I:** Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

**UNIT-II:** Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

**UNIT-III:** Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

**UNIT-IV:** Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

**UNIT-V:** Principles and practices of nematode management; integrated nematode management.

**UNIT-VI:** Emerging nematode problems, Importance of nematodes in international trade and quarantine.

**PRACTICAL**

Studies on kinds of nematodes- free-living, animal, insect and plant parasites; nematode extraction from soil; extraction of migratory endoparasites, staining for sedentary endoparasites; examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology.

**TEACHING METHODS/ACTIVITIES**

Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READING**

1. Dropkin, V. H. 1980. An Introduction to Plant Nematology. John Wiley & Sons, New York.
2. Maggenti, A. R. 1981. General Nematology. Springer-Verlag, New York.
3. Perry, R. N. & Moens M. 2013. Plant Nematology. 2nd Ed. CABI Publishing: Wallingford, UK. Perry, R. N., Moens, M. & Starr, J. L. 2009. Root-knot nematodes, CABI Publishing: Wallingford, UK.
4. Thorne, G. 1961. Principles of Nematology. McGraw Hill, New Delhi.
5. Walia, R. K & Bajaj H. K. 2003. Text Book on Introductory Plant Nematology. ICAR, New Delhi.
6. Walia, R. K. & Khan, M. R. 2018. A Compendium of Nematode Diseases of Crop Plants.
7. ICAR-AICRP (Nematodes), IARI, New Delhi.

## NEMAT 512 NEMATOLOGICAL TECHNIQUES 3 (1+2)

**OBJECTIVE**

Understanding the principles, theoretical aspects and developing skills in nematological techniques.

**COURSE OUTCOME**: After completition of course student develop skills in nematological techniques.

**THEORY**

**UNIT-I:** Principles and use of light, scanning and transmission electron microscopes, and other laboratory equipments.

**UNIT-II:** Survey and surveillance methods; collection of soil and plant samples; techniques for extraction of nematodes from soil and plant material; estimation of population densities.

**UNIT-III:** Killing, fixing, clearing and mounting nematodes; measurements, preparation of perineal patterns, vulval cones of cyst nematodes, en-face views and body section of nematodes.

**UNIT-IV:** In vitro and in vivo culturing techniques of plant parasitic, bacteriophagous, mycophagus and omnivorous nematodes.

**UNIT-V:** Staining nematodes in plant tissues; microtomy for histopathological studies; collection of plant root exudates and their bioassay; preparation of plant materials for exhibition.

**UNIT-VI:** Application of molecular techniques in Nematology.

**PRACTICAL**

Collection of soil and plant samples; extraction of nematodes from soil by Baermann funnel, sieving and decanting, elutriation and sugar centrifugal methods; extraction of cysts from soil; extraction of nematodes from plant material; estimation of population densities; staining plant material for nematodes; killing and fixing nematodes, clearing nematodes by slow and Seinhorst's methods; preparation of temporary and permanent mounts; measurements, drawing, microphotography, special preparation of nematodes - perineal patterns, vulval cones, en-face and body sections; collection of root exudates, preparation of exhibits of nematode diseased plant material, in vitro culturing techniques of nematodes- callous culture, excised root and carrot disc techniques.

**TEACHING METHODS/ACTIVITIES**: Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Ayoub, S. M. 1981. Plant Nematology – An Agricultural Training Aid.
2. Barker, K. R., Carter, C. C. & Sasser, J. N. 1985. An Advanced Treatise on Meloidogyne. Vol. II. Methodology. International Meloidogyne Project, NCSU, Raleigh. USA.
3. Manzanilla-López, R. H. & Marbán-Mendoza, N. 2012. Practical Plant Nematology, Montecillo, Texcoco : Biblioteca Basica de Agricultura.
4. Southey, J. F. 1986. Laboratory Methods for Work with Plant and Soil Nematodes. HMSO, London.

5. Sikora, R. A, Coyne, D., Hallman, J. and Timperm P. 2018. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture.3rd edn. CABI Publishing, England.
6. Subbotin, S. A., Mundo-Ocampo, M., Baldwin, J. 2010. Systematics of The Genus Heterodera in Systematics of Cyst Nematodes (Nematoda: Heteroderinae), Part B, Series: Nematology Monographs and Perspectives, Volume: **8B**, Brill.
7. Zuckerman, B. M., Mai, W. F. & Harrison, M. B. 1985. Plant Nematology Laboratory Manual. Univ. of Massachusetts.

## NEMAT-513 STRUCTURAL ORGANIZATION OF NEMATODES 3 (2+1)

**OBJECTIVE**

Familiarization with structural organization of nematode body so as to enable the students to understand biology, physiology and classification of nematodes.

**COURSE OUTCOME**: After completition of course student will the knowledge of structural organization of nematode body.

**THEORY**

**UNIT-I:** Introduction and general organization of nematode body; Morphology and anatomy of nematode cuticle, hypodermis, musculature and pseudocoelom.

**UNIT-II:** Digestive system- structural variations of stoma, oesophagus, intestine and rectum in nematodes.

**UNIT-III:** Reproductive system- Variations in female and male reproductive systems, types of reproduction, spermatogenesis and oogenesis.

**UNIT-IV:** Types and structure of excretory-secretory systems; nervous system and associated sense organs.

**UNIT-V:** Embryogenesis, Cell lineage and postembryonic development; Process of hatching and moulting.

**PRACTICAL**

Studies on variations in nematode shapes and sizes, morphological details of cuticle, cuticular markings and ornamentation, variations in stoma, oesophagus, rectum; types and parts of female and male reproductive systems, sense organs, and excretory system.

**TEACHING METHODS/ACTIVITIES**: Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Bird, A. F. & Bird, J. 1991. The Structure of Nematodes. Academic Press, New York.
2. Chitwood, B. G. & Chitwood, M. B. 1950. An Introduction to Nematology. Univ. Park Press, Baltimore.
3. Maggenti, A. R. 1981. General Nematology. Springer-Verlag, New York.
4. Malakhov, V. V. 1994. Nematodes: Structure, Development, Classification and Phylogeny. Smithsonian Institution Press, Washington DC.

## NEMAT-521 NEMATODE SYSTEMATICS 3 (2+1)

**OBJECTIVE**

Understanding concepts in nematode taxonomy, development of skills in the identification of plant parasitic nematodes up to genera and species levels.

**COURSE OUTCOME:** After completition of course student will have experience on the knowledge of nematode taxonomy and development.

**THEORY**

**UNIT-I:** Gross morphology, principles of nematode taxonomy -levels of taxonomy, systematics vs. taxonomy, morpho-taxonomy, molecular taxonomy, identification, classification, taxonomic categories, taxonomic characters, morphometry, Zoological nomenclature, species concept and speciation (allopatric and sympatric).

**UNIT-II:** Taxonomic position of nematodes and their relationships with allied groups; Classification and diagnoses of nematodes up to ordinal rank (Secernentea and Adenophorea)

**UNIT-III:** Taxonomy of free living nematodes

**UNIT-IV:** Classification of plant parasitic nematodes; Order Tylenchida and diagnoses of its sub-orders, super families, families and important genera; Order Aphelenchida, Dorylaimida and Triplonchida and diagnoses of their important genera.

**PRACTICAL**

Collection of soil and plant samples from different habitats, processing and preservation of samples; and preparation of temporary mounts, processing of nematode specimens and permanent mounts. Preparation of en face view and TS of nematodes, perineal pattern of root knot nematodes and cone-top structure for cyst nematodes.

Identification of soil and plant nematodes from nematode suspension and mounted slides. Camera lucida drawing of nematodes, measurement of nematodes using traditional as well as image analyzing software. Procedures for PCR- Taxonomy

**TEACHING METHODS/ACTIVITIES**

Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Ahmad, W. & Jairajpuri, M. S. 2010. Mononchida: The Predatory Soil Nematodes, Series: Nematology Monographs and Perspectives, Volume: **7**, Brill.
2. Geraert, E. 2006. Tylenchida. Brill.
3. Hunt, D. J. 1993. Aphelenchida, Longidoridae and Trichodoridae – their Systematics and Bionomics. CABI, Wallingford.
4. Jairajpuri, M. S. & Ahmad, W. 1992. Dorylaimida: Free-Living, Predaceous and Plant-Parasitic Nematodes, Brill.
5. Mai, W. F., Mullin, P. G., Lyon, H. H., and Loeffler, K. 1996. Plant-Parasitic Nematodes: A Pictorial Key to Genera, 5th ed., Cornell University Press, London
6. Siddiqi, M. R. 2000. Tylenchida: Parasites of Plants and Insects. 2nd Ed. CABI, Wallingford.

| NEMAT-522 | NEMATODE DISEASES OF CROPS | 3(2+1) |
|---|---|---|

**OBJECTIVE**

To impart basic knowledge about the causal organism, nature of damage, symptoms and control of nematode diseases of agricultural and horticultural crops.

**COURSE OUTCOME**: After completition of course student will be having knowledge about detection and diagnosis of nematode diseases in field.

**THEORY**

Diagnosis of causal organism, distribution, host range, biology and life cycle, nature of damage, symptoms, interaction with other organisms, and management of nematode diseases in different crops

**UNIT-I:** Cereal crops- Ear-cockle and tundu diseases of wheat, molya disease of wheat and barley; rice root nematode, rice root-knot and cyst nematode problems, ufra and white tip diseases of rice; lesion nematodes, cyst nematodes of maize and sorghum.

**UNIT-II:** Pulses, Sugar, Fibre, Fodder and Oilseed crops- Pigeon pea cyst nematode, root knot nematode, reniform nematode, lesion, lance nematode, sugarbeet cyst and soybean cyst nematode problems.

**UNIT-III:** Vegetable crops- root-knot disease, reniform nematode, potato cyst nematode; stem and bulb nematode. Nematode problems of protected cultivation.

**UNIT-IV:** Fruit crops- root-knot nematode, reniform nematode, slow decline of citrus. Flowersroot-knot nematode, foliar nematodes, bulb nematodes, Mushroom- nematode problems

**UNIT-V:** Plantation, medicinal and aromatic crops- burrowing nematode problem of banana, spices and condiments, root-knot and lesion nematode problems of coffee and tea, red ring disease of coconut. Forests- Pine wilt disease.

**PRACTICAL**

Diagnosis of causal organisms; identification of different life cycle stages; study of symptoms and histopathology of nematode damage in different crops, study tours for field diagnosis of nematode problems.

**TEACHING METHODS/ACTIVITIES**: Classroom teaching and laboratory practicals.

**SUGGESTED READINGS**

1. Bhatti, D. S. & Walia, R. K. 1992. Nematode Pests of Crops. CBS, New Delhi.
2. Bridge, J. and Starr, J. 2007. Plant Nematodes of Agricultural Importance, Manson Publishing.
3. Ciancio, A. and Mukerji, K. 2008. Integrated Management and Biocontrol of Vegetable and Grain Crops Nematodes, Springer.
4. Parvatha Reddy. P. 2008. Diseases of Horticultural Crops: Nematode Problems and their Management, Scientific Publishers, 380pp.
5. Perry, R N and Moens, M 2006. Plant Nematology, CABI.
6. Perry, R. N., Moens, Maurice, and Starr, J. L. 2009. Root-knot Nematodes, CABI Publishing.
7. Swarup, G. and Dasgupta, D.R. 1986. Plant Parasitic Nematodes of India. Ravi Sachdeva at Allied Publishers Pvt. Ltd., New Delhi.

## NEMAT-523 NEMATODE ECOLOGY 3 (2+1)

**OBJECTIVE**

To understand the life of plant parasitic nematodes in their environment; their survival strategies, and how to exploit these for their control.

**COURSE OUTCOME**: After completition of course student will have experience on the knowledge of nematodes ecology and habitat.

**THEORY**

**UNIT-I:** Definition and scope; components of environment; evolution of nematodes; ecological classification, prevalence, distribution and dispersal of nematodes.

**UNIT-II:** Role of nematodes in the food web; habitat and niche characteristics; community analysis and population estimation models.

**UNIT-III:** Effects of abiotic and biotic factors on nematodes.

**UNIT-IV:** Environmental extremes and nematode behaviour- aggregation, swarming, orientation, feeding and reproduction.

**UNIT-IV:** Survival strategies of nematodes in adverse environment and absence of host.

**UNIT-V:** Modeling population dynamics and relations with crop performance; ecological considerations in nematode management, data interpretation and systems simulation.

**PRACTICAL**

Study of nematode fauna in varied agro-ecological systems, community analysis of nematode populations, laboratory exercises on influence of abiotic factors on movement and hatching, green-house experiments on effect of abiotic factors on nematode populations and plant growth.

**TEACHING METHODS/ACTIVITIES**: Classroom teaching with AV aids, group discussion, oral presentation by students.

**READING MATERIALS**

1. Croll, N. A. 1970. The Behaviour of Nematodes: The Activity, Senses and Responses. Edward Arnold, London.
2. Croll, N. A. & Mathews, B. E. 1977. Biology of Nematodes.
3. Blackie, G. & Lee, D. L. 2002. The Biology of Nematodes. Taylor & Francis, London.
4. Gaugler, R. and Bilgrami, A. L. 2004. Nematode Behaviour, CABI, UK
5. Norton, D. C. 1978. Ecology of Plant Parasitic Nematodes. John Wiley.
6. Poinar. G. 1983. Natural History of Nematodes. Prentice Hall, Englewood Cliffs.
7. Wallace, H. R. 1973. Nematode Ecology and Plant Disease. Edward Arnold, London.

## NEMAT-531 NEMATODE BIOLOGY AND PHYSIOLOGY 3 (2+1)

**OBJECTIVE**

To develop understanding of life cycle patterns, feeding and metabolic processes in hytonematodes which have implications in their management.

**COURSE OUTCOME:** After completition of course student will have experience on the knowledge of nematodes biology and physiology.

**THEORY**

**UNIT-I:** Host finding and invasion, feeding, hatching, moulting; life cycle patterns in different types of nematodes.

**UNIT-II:** Types of reproduction, gametogenesis, embryogenesis and post embryogenesis.

**UNIT-III:** Chemical composition of nematodes, hydrolytic enzymes, pseudocoelom and function of transport.

**UNIT-IV:** Physiology of digestive system, intermediary metabolism.

**UNIT-V:** Osmoregulation, physiology of excretory-secretory and neuromuscular systems.

**PRACTICAL**

Studies on embryogenesis and post-embryogenesis, hatching, moulting, life cycle development, feeding, enzymatic assay by electrophoresis.

**TEACHING METHODS/ACTIVITIES**

Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Croll, N. A. 1970. The Behaviour of Nematodes: The Activity, Senses and Responses. Edward Arnold, London.
2. Croll, N. A. & Mathews, B. E. 1977. Biology of Nematodes.
3. Blackie, G. and Lee, D. L. 2002. The Biology of Nematodes. Taylor & Francis, London.
4. Lee, D. L. & Atkinson, H. J. 1976. Physiology of Nematodes. MacMillan, London.
5. Perry, R. N. & Wright, D. J. 1998. The Physiology and Biochemistry of Free- living and Plant Parasitic Nematodes. CABI, Wallingford.
6. Wallace, H. R. 1963. The Biology of Plant Parasitic Nematodes. Edward Arnold, London.

## NEMAT-532 NEMATODE INTERACTIONS WITH OTHER ORGANISMS 3 (2+1)

**OBJECTIVE**

To understand the role of nematodes in disease complexes involving fungal, bacterial, viral and other organisms.

**COURSE OUTCOME**: After completition of course student will have improved knowledge about relationship between nematodes, fungi, bacteria and virus.

**THEORY**

**UNIT-I:** Concept of interaction and its importance in disease complexes and their management involving nematode and other organisms.

**UNIT-II:** Interaction of plant parasitic nematodes with wilt causing fungal pathogens and microfungi.

**UNIT-III:** Interaction of plant parasitic nematodes with root rot and other fungal pathogens.

**UNIT-IV:** Interaction of plant parasitic nematodes with bacterial pathogens, other nematode species and arthropods.

**UNIT-V:** Virus transmission by nematodes.

**PRACTICAL**

Green-house experiments to study the role of plant parasitic nematodes in wilt/rot causing fungal and bacterial pathogens.

**TEACHING METHODS/ACTIVITIES**: Classroom teaching with AV aids, group discussion, field visit and exposure visit

**SUGGESTED READINGS**

1. Mondia, J. L. and Timper, P. 2016. Interactions of microfungi and plant parasitic nematodes. In: Biology of Microfungi (De-Wei-Lei Ed.). Springer Publications
2. Khan, M. W. 1993. Nematode Interactions. Chapman & Hall, New York.
3. Lamberti, F., Taylor, C. E. & Seinhorst, J. W. 1975. Nematode Vectors of Plant Viruses.
4. Sasser, J. N. & Jenkins, W. R. 1960. Nematology: Fundamentals and Recent Advances with Emphasis on Plant Parasitic and Soil Forms. Eurasia Publ. House, New Delhi

## NEMAT-533 NEMATODE MANAGEMENT 3 (2+1)

**OBJECTIVE**

To impart comprehensive knowledge about the principles and practices of nematode management.

**COURSE OUTCOME**: After completition of course student will have the knowledge on management of plant parasitic nematodes in open fields, orchards and protected cultivation.

**THEORY**

**UNIT-I:** Concepts and history of nematode management; crop loss estimation, ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis.

**UNIT-II:** Chemical methods- nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use.

**UNIT-III:** Cultural practices- crop rotations and cropping sequences, fallowing, flooding, soil solarisation, time of sowing, organic amendments of soil, bio- fumigation, antagonistic and trap crops, sanitation, *etc*.

Physical methods- use of heat, hot water treatment and other methods of disinfestations of planting material.

**UNIT-IV:** Biological methods- concepts and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use; phytotherapeutic methods – use of antagonistic plants and antinemic plant products.

**UNIT-V:** Genetic methods- plant resistance; legal methods- quarantine regulations; integrated nematode management- concepts and applications.

**PRACTICAL**

In vitro screening of synthetic chemicals and plant products for nematicidal activity, and their application methods; methods for screening of crop germplasm for resistance against nematodes, laboratory exercises on biocontrol potential of fungal, bacterial parasites, and predacious fungi and nematodes.

**TEACHING METHODS/ACTIVITIES**

Classroom teaching with AV aids, group discussion, oral presentation by students.

**SUGGESTED READINGS**

1. Bhatti, D. S. & Walia, R. K. 1994. Nematode Pest Management in Crops. CBS, New Delhi.
2. Brown, G. L. 1977. The Nematode Destroying Fungi. CBP, Guelph.
3. Brown, R. H. & Kerry, B. R. 1987. Principles and Practice of Nematode Control in Crops. Academic Press, Sydney.
4. Chen, Z. X., Chen, S. Y. & Dickson, D. W. 2004. Nematology: Advances and Perspectives. Vol. **II**: Nematode Management and Utilization. CABI, Wallingford.
5. Perry RN & Moens M. 2013. Plant Nematology. 2nd Ed., CABI, Wallingford, London. Starr JL, Cook R & Bridge J. 2002. Plant Resistance to Parasitic Nematodes. CABI, Wallingford.
6. Stirling, G. R. 2014. Biological Control of Plant parasitic Nematodes, 2nd Ed., CAB International, UK.
7. Whitehead, A. G. 1997. Plant Nematode Control. CABI, Wallingford.

# AGRICULTURE UNIVERSITY, JODHPUR

**JODHPUR-342304, RAJASTHAN**

**www.aujodhpur.ac.in**