

Restructured and Revised Syllabus of PG Programme
M.Sc. FORESTRY IN FOREST BIOLOGY AND TREE IMPROVEMENT
Course Contents

Semester 1					
Code	Title	Theory	Internal	Practical/ Term Paper	Total
Major Courses					
SOA/FCMC/501	Applied Forest Tree Improvement	60 (2)	20	20 (2+1)	100 (3)
SOA/FCMC/502	Forest Ecology and Biodiv. Management	60 (2)	20	20 (2+1)	100 (3)
SOA/FCMC/503	Breeding Methods in Forest Trees	60 (2)	20	20 (2+1)	100 (3)
SOA/FCMC/504	Reproductive Biology of Forest Trees	60 (2)	20	20 (2+1)	100 (3)
Supporting Course					
SOA/FESC/511A	General Statistical Methods and Computer Application	60 (2)	20	20 (2+1)	100 (3)
Common Courses					
SOA/FECC/01	Library and Information Services	-	40	60 (0+1)	100 (1)
SOA/FECC/02	Technical Writing & Communication Skills	-	40	60 (0+1)	100 (1)
SOA/FECC/03	Intellectual Property & Its Management in Agriculture	60	40	- (1+0)	100 (1)
SOA/FECC/04	Basic Concepts in Laboratory Techniques	-	40	60 (0+1)	100 (1)
SOA/FECC/05	Agricultural Research, Research Ethics & Rural Development Programmes	60	40	- (1+0)	100 (1)
		Total Marks and Credits			1000 (20)
Semester II					
Major Courses					
SOA/FCMC/505	Tree Seed Orchard	60	20	20 (2+1)	100 (3)
SOA/FCMC/506	Quantitative Genetics in Forest Tree Breeding	60	20	20 (2+1)	100 (3)
SOA/FCMC/508	Biotechnology in Forestry	60	20	20 (2+1)	100 (3)
Minor Courses					
SOA/FEMC/01	Silviculture	60	20	20 (2+1)	100 (3)
SOA/FEMC/02	Forest Biometry	60	20	20 (1+1)	100 (2)
SOA/FEMC/03	Agroforestry System	60	20	20 (2+1)	100 (3)
Supporting Courses					
SOA/FCSC/511B	Experimental Designs	60	20	20 (2+1)	100 (3)
		Total Marks and Credits			700 (20)
Semester III					
SOA/FCMC/509	Clonal Forestry	60	40	- (2+0)	100 (2)
SOA/FCMC/510	Forest Ecophysiology	60	20	20 (2+1)	100 (3)
SOA/FCMC/511	Physiology of Woody Plants	60	20	20 (2+1)	100 (3)
SOA/FCMC/512	Breeding for Insect Pest and Disease Resistance in Trees	60	20	20 (2+1)	100 (3)
SOA/FCMC/591	Master's Seminar	-	-	100 (1)	100 (1)
SOA/FCMC/599A	Research Review (Master Thesis)	-	-	100 (7)	100 (7)
		Total Marks and Credits			600 (19)
Semester IV					
SOA/FEMC/513	Tree Seed Technology	60	20	20 (2+1)	100 (3)
SOA/FE/599B	Master's Research (Thesis)	-	-	100 (23)	100 (23)
		Total Marks and Credits			300 (26)

SEMESTER - I

MAJOR COURSES

SOA/FCMC/501 - FOREST BIOLOGY AND TREE IMPROVEMENT

I - Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Applied Forest Tree Improvement	SOA/FCMC/501	2+1	60	20	20	100 (3)

IV Aim of the Courses

To acquaint the students about general principles of tree breeding with examples of important trees.

V –Theory

Unit I

General concept of forest tree breeding, tree improvement and forest genetics.

Unit II

Reproduction in forest trees, dimorphism, pollination mechanism. Pollen dispersal, pollinators. Attract ants for pollinators.

Unit III

Variation in trees, importance and its causes. Natural variations as a basis for tree improvement. Geographic variations–Ecotypes, clines, races and land races.

Unit IV

Selective breeding methods- mass, family, within family, family plus within family. Plus tree selection for wood quality, disease resistance and Agroforestry objectives. Selection strategies and choice of breeding methods and progress in selective breeding in forest trees.

Unit V

Seed orchards – type, functions and importance, Genetic testing- mating designs and field designs. Progeny and clone testing estimating genetic parameters and genetic gain, clonal and breeding values. Average performance of half sibs and fullsibs. GxE interaction in trees.

Unit VI

Heterosis breeding: inbreeding and hybrid vigour. Manifestation and fixation of heterosis. Species and racial hybridization. Indian examples – *Teak, Shisham, Eucalypts, Acacias, poplar*, etc.

Unit VII

Polyploidy, aneuploidy and haploidy in soft and hard wood species. Induction of polyploidy.

Unit VIII

Elements of biotechnology in tree improvement.

VI - Practical –

- Floral biology, modes of reproduction and modes of pollination in forest trees.
- Estimating pollen viability. Controlled pollination and pollen handling;
- Manipulation of flowering through hormones;
- Identification of ecotypes, races and land-races in natural forest;
- Visit to species, provenance and progeny trials;
- Selection of superior phenotypes;
- Marking of candidate trees, plus trees and elite trees;
- Visit to seed orchards;
- Comparison of parents and their putative hybrids;
- Induction of polyploidy through colchicine treatment;
- In-vitro propagation, study of molecular markers.
- Floral biology, modes of reproduction and modes of pollination in forest trees.

VIII - Suggested Readings –

- Dutta M and Saini GC. 2009. Advances in Forestry Research in India, Vol. XXX. Forest Tree Improvement and Seed Technology. International Book Distributors.
- Finkeldey R and Hattemer HH. 2006. Tropical Forest Genetics. Springer.
- Mandal AK and Gibson GL. (Eds). 1997. Forest Genetics and Tree Breeding. CBS. Sedgley M and Griffin AR. 1989. Sexual Reproduction of Tree Crops. Academic Press.
- Surendran C, Sehgal RN and Paramathma M. 2003. Text Book of Forest Tree Breeding. ICAR. White TL, Adams WT and Neale DB. 2007. Forest Genetics. CABI, UK.
- Wright JW. 1976. Introduction to Forest Genetics. Academic Press.
- Zobel BJ and Talbert J. 1984. Applied Forest Tree Improvement. John Wiley and Sons.

SOA/FCMC/502 - FOREST ECOLOGY AND BIODIVERSITY MANAGEMENT

I - Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Forest Ecology and Biodiversity Management	SOA/FCMC/502	2+1	60	20	20	100 (3)

IV - Aim of the Courses

To develop understanding among students about ecological aspects of forest, conservation of forest resources and biodiversity, consequences of depleting biodiversity and concept of sustainability.

V - Theory

Unit I

Hierarchy issues in ecology and ecosystem. Advanced topics in forest ecology including forest population, forest community dynamics, forest community structure and analysis, forest productivity, ecology of forest landscapes spatial heterogeneity and ecological succession.

Unit II

Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserve). Climate change, Global warming and forests. Green house effect and its consequences. Ozone depletion. Conservation laws and acts. Forest genetics resources of India: timber and non timber species. Survey exploration and sampling strategies Phytogeography and vegetation types of India.

Unit III

Documentation and evaluation of forest genetical resources (FGR), in situ and ex situ conservation of gene resources. Phytodiversity and its significance to sustainable use. Handling and storage of FGR. Intellectual property rights. Quarantine laws and FGR exchange.

VI - Practical

- Study of forest community structure and its successional status;
- Estimation of productivity of forest ecosystem;
- Study tours to different regions of the state to study forest vegetation;
- Collection and preservation of specimen, Methods of vegetation analysis;
- Measurement of biomass and productivity;
- Quantification of litter production and decomposition;
- Visit to national parks, wildlife sanctuaries. Botanical gardens and arboreta.

VII - Suggested Reading

- Avery TE and Burkhardt H. 2001. Forest Measurements. McGraw-Hill Education.
- Barnes BV, Zak DR, Denton SR and Spurr SH. 1998. Forest Ecology. Wiley.
- Jha BC, Pandey BN, Jaiswal K, Katiha PK, Pandey PN and Sharma AP. 2012. Biodiversity: Issues Threats and Conservation. Narendra Publishing House, Delhi.
- Kumar Biju. 2013. Biodiversity and Taxonomy. Narendra Publishing House, Delhi. Larocque GR. 2016. Ecological Forest Management Handbook (Applied Ecology and Environmental Management). Taylor & Francis.
- Mahato B, Pandey BN, Singh LB, Pandey PN and Singh RK. 2010. Text Book of Environmental Pollution. Narendra Publishing House, Delhi.

- Mikusiński G, Roberge JM and Fuller R. 2018. Ecology and Conservation of Forest Birds (Ecology, Biodiversity and Conservation). Cambridge University Press.
- Pandey PN. 2009. Biodiversity and Environment Ecology. Narendra Publishing House, Delhi. Perry DA, Oren R and Hart SC. 2008.
- Forest Ecosystems. 2nd ed. Baltimore: Johns Hopkins University Press. Young RA and Giese RL. 2003. Introduction to Forest Ecosystem Science and Management. Wiley.

SOA/FCMC/503 - BREEDING METHODS IN FOREST TREES

I - Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Breeding Methods in Forest Trees	SOA/FCMC/503	2+1	60	20	20	100 (3)

IV - Aim of the Courses

To acquaint the students about the concepts of sub-selection, population structure for breeding and production, genetic testing and making designs.

V - Theory

Unit I

Genetic constitution of tree populations, half-sib, full-sib family in trees. HardyWeinberg equilibrium, changes in gene frequency through selection, migration, mutation and population sizes.

Unit II

Long-term and short-term breeding populations. Selective breeding methods- mass, family, within family, family plus within family. Grading system of plus trees in natural stands and plantations selection index, regression systems, mother tree selection and subjective evaluation. Selection for different traits.

Unit III Genetic testing programmes – mating designs, complete designs – nested designs, factorial, single pair mating, full diallel, half diallel and partial diallel, incomplete pedigree designs – open pollinated mating and polycross mating. Improvement through progeny testing.

Unit IV

Experimental designs in genetic testing. Breeding methods for wood quality, diseases and pest resistance, drought and salt resistance. Testing procedures for genetic advancement. Marker assisted selection.

Unit V

Tree improvement case histories.

VI -Practical

- Half-sib, full-sib family in trees;
- Grading system of plus trees in natural stands;
- Mating designs, complete pedigree designs – nested designs, factorial, single pair mating, full diallel, half diallel and partial diallel, incomplete pedigree designs – open pollinated mating and polycross mating;
- Selection for biotic and abiotic stresses.

VII - Suggested Reading

- Acquaah G. 2012. Principal of Plant Genetics and Breeding. John Wiley & Sons, Ltd, UK.
- Falconer DS and Mackay TFC. 1995. Introduction to Quantitative Genetics. 4th edition. Longman, Essex
- Mandal AK and Gibson GL. 2002. Forest Genetics and Tree breeding. CBS Publishers
- Namkoong G, Kang HC and Brouard JS 1988. Tree breeding: Principles and Strategies. Springer Verlag, New York.
- Surendran C, Sehgal RN and Parmathama M. (Eds.). 2003. A Text Book of Forest Tree Breeding. ICAR.
- White TL and Hodge GR 1989. Predicting Breeding Values with Applications in Forest Tree Improvement. Kluwer Academic Publishers, Boston.
- White TL, Adams WT and Neale DB. 2007. Forest Genetics. CABI Wright JW. 1962. Genetics of Forest Tree Improvement. Academic Press.
- Wright JW. 1976. Introduction to Forest Genetics. Academic Press. Zobel BJ and Talbert J. 1984.
- Applied Forest Tree Improvement. John Wiley and Sons.

SOA/FCMC/504 - REPRODUCTIVE BIOLOGY OF FOREST TREES

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical	Total
Reproductive Biology of Forest Trees	SOA/FCMC/504	2+1	60	20	20 (2+1)	100 (3)

IV - Aim of the Courses

To impart the knowledge of reproduction in forest tree species to the students and to make them understand the mechanism of breeding and sex expression.

V – Theory

Unit I

Importance and application of reproductive biology in tree breeding. Crop characteristics-growth and development (both vegetative and reproductive).

Unit II

Floral diversity and pollination. Flower types pollination syndromes and their evolution. Plant – pollinator systems. Diversity of pollination syndromes in selected plant families. Modes of reproduction-sexual, asexual and vegetative and their breeding systems and sex expression, monoecy, dioecy and its evolution.

Unit III

Environmental effects on sex expression. Floral biology. Modes of pollination self and out-crossing. Floral attractants and rewards biology of floral and extra floral nectaries examples of plant insect interactions involving pollination. Floral characteristics of the main pollination syndromes.

Unit IV

Environmental effects on sex expression. Floral biology initiation and development. Modes of pollination self and out-crossing.

Unit V

Fertilization in hardwood and softwood species. Seed dispersal and gene flow.

VI. Practical

- Sex expression in forest trees;
- Out crossing mechanisms in forest trees;
- Measurement of pollen flow in wind-pollinated and insect-pollinated species;
- Pollen viability and fertility;
- Seed dispersal mechanism.

VII. Suggested Reading

- Almeida OJG, Cota K Sánchez JH and Paoli AAS. 2013. The systematic significance of floral morphology, nectaries and sugar nectar concentration in epiphytic cacti of tribes Hylocereeae and Rhipsalideae (Cactaceae). *Persp. Plant Ecol. Evol. Syst.* 15: 255-268.
- Barrett SCH. 2006. Ecology and Evolution of Flowers [electronic resource]. (Eds.) L.D. Harder SCH. Barrett. Oxford Univ. Press, New York, U.S.A.
- Bawa KS and Hadley M. 1990. Reproductive Ecology of Tropical Forest Plants. UNESCO Man and Biosphere Series.
- Briggs and Walters SM. 1984. Plant Variation and Evolution.
- Cláudia Inês da Silva and Helena Maura Torezan Silingardi. 2006. Reproductive Biology of Tropical Plants – International Commission On Tropical Biology and Natural Resources. Encyclopedia of Life Support Systems (EOLSS) FAO. 1985.
- Forest Tree Improvement, FAO Publication.
- Khosla PK. 1981. Advances in Forest Genetics. Ambika Publ., New Delhi.
- Mandal AK and Gibson GL. (Eds.). 1997. Forest Genetics and Tree Breeding. CBS.
- Sedgley and Griffin. 1989. Sexual Reproduction of Tree Crops.
- Spencer C H, Barrett, Robert I, Colautti and Christopher G Eckert. 2007. Plant Reproductive Systems and Evolution during Biological Invasion. Wiley Online Library. (<https://doi.org/10.1111/j.1365-294X.2007.03503.x>)

SUPPORTING COURSES

SOA/FESC/511A – GENERAL STATISTICAL METHODS AND COMPUTER APPLICATIONS

I – Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
General Statistical Methods and Computer Applications	SOA/FESC/511A	2+1	60	20	20	100 (3)

IV – 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 general statistical methods and statistical inference that would help them in understanding the importance of statistical methodology. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation of results.

V – Theory

Unit I

Review of probability. Random variable and mathematical expectation. Discrete and continuous probability distributions, viz., Binomial, Poisson and Normal distributions.

Unit II

Correlation and regression, Rank correlation, Non-linear regression, Partial and multiple correlation coefficient, Intra class correlation, Multiple linear regression.

Unit III

Introduction to theory of estimation, Testing of statistical hypothesis: chi-square, t and F distributions. Tests of significance based on chi-square, t and F tests. Large sample tests, Fisher Z transformation.

Unit IV

Analysis of variance: One way and two way classification. Design of Experiments: Basic Principles of design of experiments, Completely Randomised Design, Randomised Block Design, Latin Square Design. Elementary idea of factorial experiments. Estimation of genetic parameters from ANOVA table.

Unit V

Non-parametric tests: Sign test, Wilcoxon test, Mann-Whitney U-test, Wald Wolfowitz run test, Median test, Kruskal- Wallis test. MS Excel, Introduction to computer softwares.

VI – Practical

- Random variable and mathematical expectation;
- Fitting of distributions, viz., Binomial, Poisson, Normal;
- Correlation and regression;
- Non-linear regression
- Multiple linear regression;
- Testing of hypothesis based on chi square, t and F tests. Large sample tests. Completely Randomised Design, Randomised Block Design, Latin Square Design and Factorial experiments. Non-parametric tests. Exercises based on computer software.

VII – Suggested Reading

- Aggarwal BL. 1996. Basic Statistics. Wiley Eastern Limited, New Age International Ltd.
- Bansal ML, Singh S, Singh TP and Kumar R. 2004. Statistical Methods for Research Workers. Kalyani Publishers.
- Chandel SRS. 2014. A Handbook of Agricultural Statistics. Achal Prakashan.
- Goon AM, Gupta MK and Dasgupta B. 1968. Fundamentals of Statistics, vol I, II. The World Press, Calcutta.
- Snedecor GW and Cochran WG. 1980. Statistical Methods. East West Press.

COMMON COURSES

SOA/FECC/01 – LIBRARY AND INFORMATION SERVICES

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical/ Term Paper	Total
Library and Information Services	SOA/FECC/01	0+1	-	40	60	100 (1)

IV. 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; eresources access methods.

SOA/FECC/02 -TECHNICAL WRITING AND COMMUNICATIONS SKILLS

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical/ Term Paper	Total
Technical writing and communications skills	SOA/FECC/02	0+1	-	40	60	100 (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. Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
2. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
3. Collins' Cobuild English Dictionary. 1995.
4. Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.

5. Holt, Rinehart and Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
6. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
7. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
8. Mohan K. 2005. Speaking English Effectively. MacMillan India.
9. Richard WS. 1969. Technical Writing.
10. Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
11. Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

SOA/FECC/03 -INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical/ Term Paper	Total
Intellectual Property and its Management in Agriculture	SOA/FECC/03	1+0	60	40	No Practical	100 (1)

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 FH and 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 and 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 and 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. 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; The Biological Diversity Act, 2002.

SOA/FECC/04 - BASIC CONCEPTS IN LABORATORY TECHNIQUES

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical/ Term Paper	Total
Basic Concepts in Laboratory Techniques	SOA/FECC/04	0+1	-	40	60	100 (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 vaccumets;
- 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 AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.
2. Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

SOA/FECC/05 - AGRICULTURAL RESEARCH, RESEARCH ETHICS & RURAL DEVELOPMENT PROGRAM.

I - Title	II - Code	III - Credit Hours	Theory	Internal	Practical/ Term Paper	Total
Agricultural Research, Research Ethics & Rural Development Program.	SOA/FECC/05	1+0	60	40	No Practical	100 (1)

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 GS and Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia MS. Manual on International Research and Research Ethics. CCS Haryana Agricultural University,

Hisar.

3. Rao BSV. 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.

SEMESTER II

MAJOR COURSES

SOA/FCMC/505 – TREE SEED ORCHARDS

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical	Total
Tree Seed Orchards	SOA/FCMC/505	2+1	60 (2)	20	20	100 (3)

IV - Aim of the Courses

To develop understanding among students about tree seed orchards.

Theory

Unit I

Importance of genetically improved seed in plantation forestry. Status of seed production among major plantation species. Short term supply of superior seed.

Unit II

Selection and delineation of seed stands, seed production areas, seed zones, seed ecological zones.

Unit III

Seed orchard: need, evolving seed orchards, containerized seed, hybrid and research seed orchards; first, second and advanced generation seed orchards. Seed orchard genetics: random mating, gamete exchange and parental balance. Estimation of genetic parameters from seed orchard data. Orchet age and its effect on seed production.

Unit IV

Importance of progeny testing. Establishment of seed orchards, selection and preparation of orchard site, isolation, orchard size, and designs. Seed orchard management: rouging, silvicultural practices to increase seed yield.

Unit V

Pest and disease management. Seed collection and record keeping, seed orchard registration and documentation. Importance of seed orchards in gene conservation.

VI. Practical

- Visits and study of seed orchard designs;
- Estimation of overlap in flowering among genotypes;
- Study of inter and intra-clonal variation in floral, seed characters;
- Effect of girdling on flowering;
- Plant growth regulator application for flower induction;
- Pollen viability/ fertility;
- Assessment of pollen dispersa;
- Supplemental mass-pollination;
- Effects of foliar application of fertilizers on seed set;
- Estimation of genetic parameters for a few traits;
- Estimation of parental balance.

VII. Suggested Reading

Faulkner R. 1975. Seed Orchard Forestry. Commission Bull. No. 34.

Fins L, Friedman ST and Brotschol JV. 1992. Handbook of Quantitative Forest Genetics. Kluwer.

Khosla PK. 1981. Advances in Forest Genetics. Ambika Publ., New Delhi.

Mandal AK and Gibson GL. (Eds.). 1997. Forest Genetics and Tree Breeding. CBS.

Nanson A. 2004. Genetics of Forest Tree Breeding. Agronomic Press

Surendran C, Sehgal RN and Parmathama M. (Eds.). 2003. A Text Book of Forest Tree Breeding. ICAR.
 Wright JW. 1976. Introduction to Forest Genetics. Academic Press.
 Zobel BJ and Talbert J. 1984. Applied Forest Tree Improvement. John Wiley & Sons.

SOA/FCMC/506 - QUANTITATIVE GENETICS IN FOREST TREE BREEDING

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical	Total
Quantitative Genetics in Forest Tree Breeding	SOA/FCMC/506	2+1	60	20	20	100 (3)

IV - Aim of the Courses

To impart knowledge in the field of biometry as applied to breeding, population, provinces and making experiment in forest genetics and tree breeding.

V. Theory

Unit I

Historical aspects of quantitative genetics. Inheritance of continuously varying characters, Genetic variance and its partitioning, models of gene action. Multiple factor hypothesis (Nilsson-Ehle (1908) and East (1915) experiments.

Unit II

Mating systems, population structure in random mating. Hardy Weinberg law, Effect of selection, mutation, migration, genetic drift; on genes and genotypic frequency.

Unit III

Inbreeding, effects of inbreeding in various populations. Heterosis, causes of heterosis and its utility in various plants. Unit IV Significance and estimation of genetic variance components. Heritability, its estimation by various methods and significance.

Unit V

Natural selection, fundamental theorem of natural selection (Fisher 1930). Selection responses. Correlation and its utility. Partitioning of correlation into direct and indirect effects.

Unit VI

Mating design, combining ability, general and specific combining ability and methods of its estimation.

Unit VII

Genotypic x environment interaction, its significance. Various procedures for the estimation of genotypic x environment interaction.

VI. Practical

- Exercise on polygenic inheritance;
- Proof that quantitative characters are inherited in Mendelian fashion;
- Estimation of genotypic and phenotypic variance in an experiment, estimation of additive and dominance components of variance through various procedures;
- Mating designs and estimation of components of genetic variance;
- Proof of population genetics law;
- Exercise on calculation of gene and genotypic frequency;
- Estimation of heterosis, estimation of heritability (broad sense and narrow sense) by various methods;
- Genotypic and phenotypic correlation coefficients, partitioning of correlation into direct and indirect effects;
- Estimation of general combining ability and specific combining ability;
- Estimation of genotypic x environment interaction.

VII. Suggested Reading

- Acquaah G. 2012. Principal of Plant Genetics and Breeding. John Wiley & Sons, Ltd, UK. Kute N and Shinde G. 2016. Principles of Biometrical Genetics. Daya publishing.
- Fins Lauren, Friedman ST and Brotschol JV. (Eds.). 1992. Handbook of Quantitative Forest Genetics. Springer, Netherlands.
- Gene Namkoong. 1979. Introduction to Quantitative Genetics In Forestry. Technical Bulletin No. 1588.

- Singh RK and Chaudhary BD. 1985. Biometrical Methods in Quantitative genetical Analysis. Kalyani Publishers, New Delhi.

SOA/FCMC/508 – BIOTECHNOLOGY IN FORESTRY

I - Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Biotechnology In Forestry	SOA/FCMC/508	2+1	60 (2)	20	20	100 (3)

IV - Aim of the Courses

To impart knowledge about different aspects of biotechnology in forestry

V - Theory

Unit I

Introduction. Cloning, need for cloning, problems with cloning. Traditional cloning techniques versus micro-propagation, prospects of micro-propagation in forestry. Techniques procedures and problems in micro propagation, case studies. Protocols for micro-propagation. Preconditioning of explants, surface sterilization, nutritional media, other environmental factors controlling micro-propagation, choice of explants for micro-propagation. Micro propagation of juvenile material. Micro propagation of mature trees. In-vitro propagation of plants with low sexual reproduction rates, miscellaneous application.

Unit II

Initiation and maintenance of callus. Organogenesis and somatic embryogenesis – factors influencing somatic embryogenesis-applications in forestry, Somatic seeds, encapsulation techniques. Somaclonal variation, genetic and epigenetic variation, exploitation in forestry. Cell suspension cultures. Anther and pollen cultures. Triploids through endosperm culture, embryo culture. Monoploid production by chromosome elimination. Applications of In-vitro fertilization, isolation, purification and culture of protoplasts, protoplast fusion and somatic hybridization. Cryopreservation, storage of plant genetic resources. Production of secondary metabolites by cell cultures. Meristem culture, virus free plants.

Unit III Genetic engineering – application in forestry Isozymes, restriction fragment length polymorphisms (RFLPs), randomly amplified polymorphic DNAs (RAPDs) and microsatellites. Genetic fingerprinting, Marker assisted selection. Different PCR techniques: their characteristics, with advantages and disadvantages.

Unit IV

Quantification of genetic diversity, genotype verification and delineation. Introduction of genes. Promoters and marker genes. disease resistance, herbicide tolerance and tolerance to salt and other stresses.

VI. Practical

- Introduction to tissue culture lab;
- Micropropagation: Aseptic techniques;
- Preparation of culture media, formulation of different culture media;
- Induction and maintenance of callus, regeneration of plants from callus, regeneration of plants from embryoids;
- Cell suspension culture;
- Anther and pollen culture. Quantification of tissue culture;
- Isolation and culture of protoplasts;
- Marker assisted RFLP in test trees;
- Study of PCR techniques used in tree improvement;
- Application of GENALEX 'bolt on' for excel, arlequin, PopGene and FSTAT for Wright's F-statistics and analysis of molecular variance (AMOVA).

VII. Suggested Reading

- Bajaj YPS. 1986. Biotechnology in Agriculture and Forestry. Springer Verlag, New York.
- Bonga JM and Durjan J. 1987. Cell and Tissue Culture in Forestry Vol. I & II. Martinus Nijost Publishers, Dordrecht.
- Hainer R. 1996. Biotechnology in Forest Tree Improvement. (FAO Bulletin 1994) International Book

Distributors. Dehra Dun.

- Muchugi A, Kadu C, Kindt R, Kipruto H, Lemurt S, Olale K, Nyadoi P, Dawson I and Jamnadass R. 2008. Molecular Markers for Tropical Trees, A Practical Guide to Principles and Procedures. ICRAF Technical Manual no. 9. Dawson I and Jamnadass R. eds. Nairobi: World Agroforestry Centre.
- Murphy TM and Thompson WF. 1988. Molecular Plant Development. Prentice Hall, Engleward, cliffe, New Jersey.
- Russel GE. 1988. Biotechnology of Higher Plants. Intercept publishers, Nimborne, Dorset.
- Russell Haines. 1994. Biotechnology in Forest Tree Improvement with Special Reference to Developing Countries. Food and Agriculture Organization of the United Nations, Rome.

MINOR COURSES

SOA/FEMC/01 - SILVICULTURE

I – Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Silviculture	SOA/FEMC/01	2+1	60	20	20	100 (3)

IV – Aim of the Course

To understand stand growth, development and provide knowledge regarding the application of silvicultural principles for the production and protection benefits from the forests.

V – Theory

Unit I

Forest ecosystems- Introduction to tropical/ temperate silviculture. Role of silviculture in forest and wild land management, major forest formations classification, distribution, composition and structure. Vegetation dynamics- species richness-diversity indices. Vegetation forms of India and their productivity. Forest ecosystem- structure and functioning, community development, competitive interactions in forest communities, forest succession, concepts and models of succession-Connell-Slatyer models, climax theories, tolerance.

Unit II

Ecophysiology of tree growth- effect of radiation and water relationship, mineral nutrients and temperature. Forest stand development – stand development, even aged and uneven-aged stands, age and site quality. Tree architecture and its role in stand management.

Unit III

Stand density determination-stand density indices-stand density management density management diagram, silvicultural treatments involved- thinning as a stand management tool, objectives of thinning, effects on growth and yield, thinning effect on economic yield of stands. Forest site quality evaluation-direct and indirect methods.

Unit IV

Treatment analysis-silvicultural regimes- factors influencing choice of regimes, use of system analysis to determine regimes, models for evaluating silvicultural alternatives, development of silvicultural regimes to suit management objectives, optimum management strategies, silvicultural prescriptions for maximum production regime.

VI – Practical

Visit to forest areas to study forest composition, classification, factors of locality, site quality, form and growth of forest trees- study plant succession- study stand density, changes on productivity- thinning effects

VII – Suggested Reading

- Daniel TW, Helms JA and Baker FS. 1979. Principles of Silviculture. McGraw-Hill Book Company.
- Julius E. 1992. Plantation Forestry in the Tropics. Oxford University Press.
- Khanna LS. 1996. Principle and Practice of Silviculture. International Book Distributors.
- Khanna LS. 2015. Theory and Practice of Indian Silviculture Systems. Bio-Green Publisher.
- Lamprecht. 1986. Silviculture in the Tropics. Verlag Paul Parey, Hamburg und Berlin.
- Nyland RD, Laura S, Kenefic, Kimberly K, Bohn and Susan LS. 2016 Silviculture: Concepts and Applications (III edition), Kindle Edition, USA.
- Pascal. 1988. Wet Evergreen Forests of the Western Ghats.

- Shepherd KR. 1986. Plantation Silviculture. Springer.
- Smith DM, Larson BC, Ketty MJ and Ashton PMS. 1997. The Practices of Silviculture- Applied Forest Ecology. John Wiley & Sons.

SOA/FEMC/02 - FOREST BIOMETRY

I – Title	II – Code	III - Credit Hours	Theory	Internal	Practical	Total
Forest Biometry	SOA/FEMC/02	2+1	60	20	20	100 (2)

IV – Aim of the Course

To develop understanding of students about tree and stand measurements, forest inventory and yield concepts.

V – Theory

Unit I

Measurement of tree parameters. Determination of tree age and dendrochronology for growth history and climate change studies.

Unit II

Estimation of volume, growth and yield of individual tree and forest stands. Preparation of volume tables. Application of yield and stand tables.

Unit III

Forest inventory, sampling methods adopted in forestry, Use of GIS in forest inventory. Quantification of regeneration and stand establishment. Measurement of crown density and crown ratios. Simulation techniques. Growth and yield prediction models – their preparation and applications.

VI – Practical

- Calculations of volume of felled as well as standing trees;
- Volume table preparation;
- Application of different sampling methods;
- Preparation of yield and stand table;
- Quantification of regeneration and stand establishment;
- Measurement of crown density and crown ratios;
- Crown profiling of trees and stand;
- Dendrochronological studies.

VII - Suggested Reading

- Chaturvedi AN and Khanna LS. 1994. Forest Mensuration. International Book Distributor.
- Ram Parkash 1983. Forest Surveying. International Book Distributor.
- Sharpe GW, Hendee CW and Sharpe WE. 1986. Introduction to Forestry. McGraw-Hill.
- Simmons CE. 1980. A Manual of Forest Mensuration. Bishen Singh Mahender Pal Singh, Dehradun.

SOA/FEMC/03 – AGROFORESTRY SYSTEMS

I – Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Agroforestry Systems	SOA/FEMC/03	2+1	60	20	20	100 (3)

IV – Aim of the Course

To impart knowledge on the concept of agroforestry as a sustainable land use including diagnosis and design methodologies; overview of agroforestry and case studies.

V – Theory

Unit I

Agroforestry: objectives, importance, potentials and limitations for implementations. Land capability

classification and land evaluation. Basis of classification of agroforestry systems and principles, indigenous vs. exotic, intraspecific variations, crown architecture of tropical/ temperate trees. Ideotype concept for selection of multipurpose trees. Nitrogen fixing trees. Overview and case studies of different agroforestry systems.

Unit II

Structural and functional attributes of agroforestry systems, shifting cultivation, taungya system, multiple and mixed cropping, alley cropping, silvopastoral systems, shelter-belts and windbreaks, energy plantations and home gardens.

Unit III

Role of trees in soil productivity and conservation– micro-site enrichment- litter and fine root dynamics, Nitrogen fixation and nutrient pumping. Soil productivity and management in agroforestry.

Unit IV

Community forestry and social forestry, linear strip plantations.

Unit V

Trends in agroforestry systems research and development, Diagnosis and Design –PRA-RRA tools in agroforestry problem diagnosis.

Unit VI

Climate Change mitigation and adaptation through agroforestry- climate negotiations- LULUCF- agroforestry options.

VI – Practical

- Survey and analysis of land use systems in the adjoining areas;
- Study of tree crown architecture;
- Design and plan of suitable models for improvement;
- PRA-RRA tools in agroforestry problem diagnosis.

VII – Suggested Reading

- Buck LE, Lassoie, Fernandes ECM 1999. Agroforestry in Sustainable Agri. Systems. CRC Press.
- Kumar BM and Nair PKR. 2006. Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry. Springer publication.
- Kumar BM and Nair PKR. 2013. Carbon Sequestration Potential of Agroforestry Systems: Opportunities and Challenges (Advances in Agroforestry). Springer publication.
- Nair PKR and Latt 1998. Directions in Tropical Agroforestry Research. Kluwer.
- Nair PKR, Rai MR and Buck LE. 2004. New Vistas in Agroforestry. Kluwer
- Nair PKR. 1993. An Introduction to Agroforestry. Kluwer Academic Pub.
- Ong CK and Huxley PK. 1996. Tree Crop Interactions – A Physiological Approach. ICRAF.
- Peter Huxley. 1999. Multiple Cropping with Woody and Non-Woody Plants. John Wiley and Sons Ltd, Oxford, United Kingdom.
- Tejwani KG. 1994. Agroforestry in India. Oxford & IBH Publishing Co. Pvt Ltd.
- Thampan PK. 1993. Trees and Tree Farming. Peekay Tree Crops Development Foundation.
- Young A. 1997. Agroforestry for Soil Management. CABI.

SUPPORTING COURSES

SOA/FCSC/511B - EXPERIMENTAL DESIGNS

I - Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Experimental Designs	SOA/FCSC/511B	2+1	60	20	20	100 (3)

IV - Aim of the Courses

This course is meant for students who do not have sufficient background of statistical methods. The students would be exposed to concepts of general statistical methods and statistical inference that would help them in understanding the importance of statistical methodology. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation of results.

V – Theory

Unit I

Analysis of variance: One way and two way classification. Design of Experiments: Basic Principles of design of experiments, Completely Randomised Design, Randomised Block Design, Latin Square Design. Elementary idea of factorial experiments. Estimation of genetic parameters from ANOVA table.

Unit II

Non-parametric tests: Sign test, Wilcoxon test, Mann-Whitney U-test, Wald Wolfowitz run test, Median test, Kruskal- Wallis test. MS Excel, Introduction to computer softwares.

VI. Practical

- Random variable and mathematical expectation;
- Fitting of distributions, viz., Binomial, Poisson, Normal;
- Correlation and regression;
- Non-linear regression
- Multiple linear regression;
- Testing of hypothesis based on chi square, t and F tests. Large sample tests. Completely Randomised Design, Randomised Block Design, Latin Square Design and Factorial experiments. Non-parametric tests. Exercises based on computer software.

VII. Suggested Reading

- Aggarwal BL. 1996. Basic Statistics. Wiley Eastern Limited, New Age International Ltd.
- Bansal ML, Singh S, Singh TP and Kumar R. 2004. Statistical Methods for Research Workers. Kalyani Publishers.
- Chandel SRS. 2014. A Handbook of Agricultural Statistics. Achal Prakashan.
- Goon AM, Gupta MK and Dasgupta B. 1968. Fundamentals of Statistics, vol I, II. The World Press, Calcutta. Snedecor GW and Cochran WG. 1980. Statistical Methods. East West Press.

SEMESTER III

SOA/FEMC/509 - CLONAL FORESTRY

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical	Total
Clonal Forestry	SOA/FCMC/509	2+0	60	40	No Practical	100 (2)

IV - Aim of the Courses

To provide information about genetics, conservation, biotechnological approaches for trees in clonal forestry system for higher biomass/ yield productivity

V. Theory

Unit I

Introduction to Clonal Forestry. History of clonal forestry. Clonal propagation. Clonal planting. Strategies for clonal forestry for higher productive potential.

Unit II

Juvenility and maturation, rejuvenation and maintainance, regulation of phase changes, markers of phase changes. Breeding strategies using vegetative propagation- selection and breeding for extreme genotypes. Physiological research for higher productivity of clonal forest. Field design, testing and evaluation of clones. Genetic gains from breeding with clonal option. Clonal conservation approaches- management of populations for genetic diversity and gain.

Unit III

Biotechnological approaches for clonal forestry, Plant tissue culture, micropropagation, Rejuvenation of tissues from mature trees, Testing of Clonal fidelity using molecular markers.

VI. Suggested Reading

- Ahuja MR and Libby WJ. 1993. Clonal Forestry I Conservation and Application. Springer
- Ahuja MR. 1992. Micropropagation of Woody Plants: Volume 41 (Forestry Sciences). Springer
- Ahuja MR and Libby WJ. 1993. Clonal Forestry II Genetics and Biotechnology. Springer

- Mandal AK and Gibson GL. 2002. Forest Genetics and Tree Breeding. CBS Publishers, New Delhi

SOA/FCMC/510 - FOREST ECOPHYSIOLOGY

I - Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Forest Ecophysiology	SOA/FCMC/510	2+1	60	20	20	100(3)

IV - Aim of the Courses

To understand dynamics of forest ecosystem and role of stress in forest productivity.

V. Theory

Unit I

Forest environment interactions, Forest ecosystems, Geographic and climatic factors. Environmental factors influencing forest growth and productivity. Sun and shade plants.

Unit II

Influence of temperature, water stress and nutrient availability and disturbance in the forest on tree growth and forest productivity.

Unit III

Dynamics of forest ecosystems, energy, productivity and biomass. Decomposition and nutrient cycling.

Unit IV

Stand structure and micro-climate, energy relationships canopy energy balance. Partitioning absorbed energy. Radiation penetration into and absorption by canopies. Air temperature and humidity in forests. Turbulent transfer process above forests.

Unit V

Transpiration and evapo-transpiration from forest canopies. Estimation of ET.

Unit VI

Stress – avoidance and tolerance mechanisms. Temperature stress – low temperature stress – physiology of resistance to frost. Heat stress, heat injury, heat avoidance and tolerance mechanism. Radiation stress, mechanism of shade tolerance, water logging, physiology of resistance to water logging. Drought stress, salt and ion stress.

VI. Practical

- Morphological, anatomical and physiological variations between sun and shade plants;
- Estimation of leaf area, LAI;
- Estimation of biomass production of trees of different species;
- Estimation of microclimatic elements as influenced by stand structure;
- Estimation of evapo-transpiration;
- Measurement of radiation in different types of forest and agroforestry systems.

VII. Suggested Reading

- Kozlowski TT, Kramer PJ and Pallardy GS. 1991. The Physiological Ecology of Woody Plants. Academic Press, New York.
- Kramer PJ. 1972. Plant and Soil Water Relationships. TMH Edition, Tata McGraw Hill Publ. Co., New Delhi. Ksenzhek OS and Volkov AG. 1998. Plant Energetics. Academic Press, New York.
- Lack AJ and Evans DE. 2001. Plant Biology- Instant Notes. Vina Books Pvt. Ltd., New Delhi.
- Lambers H, Chaplin FS and Pons TL. 1998. Plant Physiological Ecology. Springer, New York
- Larcher W. 2003. Physiological Plant Ecology. 4th edn, Springer-Verlag, Germany
- Luttge U. 2008. Physiological Ecology of Tropical Plants. Springer-Verlag, Germany
- Moore TC. 1989. Biochemistry and Physiology of Plant Hormones, 2nd ed. Springer Verlag, Berlin.
- Taiz L and Zeiger E. 2007. Plant Physiology, 4th ed. Sinauer Associates Inc. Publishers, Sunderland.
- Wilkins BM. 1984. Advanced Plant Physiology. ELBS/ Longman Pub. Co.

SOA/FEMC/511 - PHYSIOLOGY OF WOODY PLANTS

I - Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Forest Ecophysiology	SOA/FEMC/511	2+1	60	20	20	100(3)

IV - Aim of the Courses

To acquaint students about the concepts of physiology for understanding its use in increasing productivity of forest stands

V. Theory

Unit I

Introduction, Tree physiology. Growth, phases of growth, growth curve, factors affecting growth.- Wood formation.

Unit II

Plant cell as a structural and functional unit. Organization of cells and tissues, morphogenesis.

Unit III

Structure of leaves, stem wood, bark and roots in trees. Functions and process in plant growth and development.

Unit IV

Photosynthesis, structure of photosynthetic tissues and organs, enzyme, energetics and factors influencing photosynthesis. Photorespiration, its mechanisms and significance, factors affecting photorespiration.

Unit V

Respiration, mechanisms, enzymes, energetics and factors influencing respiration. Respiratory quotient.

Unit VI

Water relations of trees, absorption, ascent of sap. Translocation of solutes, phloem loading and phloem transport. Transpiration, mechanisms and factors influencing, regulating transpiration, antitranspirants.

Unit VII

Mineral nutrition. Mineral salt absorption and translocation, deficiency and toxicity of mineral nutrients. Diagnosis of mineral deficiency

Unit VIII

The enzymes, nomenclature and classification, structure and compositioned. Mode of action. Phytohormones, auxins, GA, cytokinins, ABA, ethylene. Biosynthesis and biochemical activity of plant hormones. Synthetic plant growth regulators. Growth retardants.

Unit IX

Nitrogen fixing trees, Nitrogen metabolism. N₂ fixation, physical and biological. Nitrogen assimilation, Amino acid and protein synthesis.

Unit X

Fat metabolism. Carbohydrate metabolism.

VI. Practical

- Preparation of growth curves of different tree seedlings;
- Study of structure of leaves;
- Measurement of photosynthesis;
- Observing structure of plant cells and leaves in C₃ and C₄ species;
- Studying stomata in different tree species and working out stomatal frequency;
- Measurement of stomatal size in different tree species;
- Estimation of transpiration rates in different trees;
- Isolation and estimation of chlorophyll;
- Observing xylem vessel size variation in tree species;
- Estimation of plant water status by different methods;
- Nutrient deficiency symptoms in tree seedlings.

VII. Suggested Reading

- Dreyer E. 2011. Forest Tree Physiology. University of Minnesota, Elsevier
- Kramer PJ and Kozlowsky TT. 1979. Physiology of Woody Plants. Academic Press.
- Kramer PJ. 1972. Plant and Soil Water Relationships. TMH Edition, Tata McGraw Hill Publ. Co., New Delhi.
- Ksenzhek OS. and Volkov AG. 1998. Plant Energetics. Academic Press, New York.

- Lack AJ and Evans DE. 2001. Plant Biology- Instant Notes. Vina Books Pvt. Ltd., New Delhi.
- Larcher W. 2003. Physiological Plant Ecology. 4th edn, Springer-Verlag, Germany
- Luttgge U. 2008. Physiological Ecology of Tropical Plants. Springer-Verlag, Germany
- Malik CP and Srivastava. 2015. Textbook of Plant Physiology. Kalyani Publishers, Mumbai
- Moore TC. 1989. Biochemistry and Physiology of Plant Hormones. 2nd ed. Springer-Verlan, Berlin.
- Noggle RG. and Fritz GJ. 2010. Introductory plant physiology. Sinauer Associates Inc. Publishers, Sunderland
- Pallardy HG. 2008. Physiology of Woody Plants. Elsevier, Amsterdam
- Taiz L and Zeiger E. 2007. Plant Physiology 4th ed. Sinauer Associates Inc. Publishers, Sunderland.
- Zimmerman MH and Brown CL. 1971. Tree structure and Function, Springer Verlag.

SOA/FCMC/512 - BREEDING FOR INSECT PEST AND DISEASE RESISTANCE IN TREES

I - Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Breeding for Insect Pest and Disease Resistance in Trees	SOA/FCMC/512	2+1	60	20	20	100(3)

IV - Aim of the Courses

To impart knowledge about mechanisms of disease and insect pest resistance in trees, breeding methodology to incorporate disease and insect pest resistance.

V. Theory

Unit I

Need for disease resistance in forest trees, Process of infection. Variability in plant pathogens. Types of resistance. Inheritance of resistance. Disease resistance mechanisms in trees, Clonal resistance. Disease resistance breeding techniques. Techniques of isolating resistant genes; developing disease resistant transgenic plants.

Unit II

History and importance of insect pest resistance, types and mechanism of resistance. Insect-tree relationships. Basis of resistance: Induced resistance and acquired resistance. Defense mechanisms against insects. Factors affecting tree pest resistance. Breeding for insect resistance.

VI. Practical

- Disease progression in relation to resistance, disease resistance in clonal plantations and seed orchards, hypersensitivity and its mechanisms, disease resistance screening;
- Screening for insect pest resistance; chemical and morphological characterization of susceptible/resistance tree species;
- Defence strategies of woody plants.

VII. Suggested Reading

- Dube HC. 2014. Modern Plant Pathology, Second Edition. Agribios, Jodhpur (India).
- Harsh NS. 2012. Disease Resistance in Genetic Material in Tree Improvement Programme. Lambert Acad. Publications.
- Heybroek HM, Stephan BR and Weissenberg KV. 1990. Resistance to Diseases and Pests in Forest Trees. IBD, Dehra Dun (India).
- Nair KSS, Sharma JK and Varma RV. 1996. Impact of Diseases and Insect Pest in Forest Trees. Parker J. 2008. Molecular Aspects of Plant Disease Resistance. Ann. Pl. Rev.,. 34. Blackwell Publications UK.
- Ross Wylie F and Martin R Speight. 2012. Insect Pests in Tropical Forestry (2nd Ed.). CABI Tropical Forests.
- Van der Plank JE. 1984. Disease Resistance in Plants. Academic Press Inc., New York.
- Van der Plank JE. 1982. Host Pathogen Interactions in Plant Disease. Academic Press Inc., New York.
- Willium M Ciesla. 2010. Forest Entomology-A Global Perspective. Wiley-Blackwell.

SOA/FCMC/591 - MASTER'S SEMINAR

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical/ Term Paper	Total
Master's Seminar	SOA/FCMC/591	0+1	-	-	100	100(1)
<ul style="list-style-type: none">Concerned department will organize in house seminars about pre-discussion of the master thesis topics.Departmental committee will discuss and finalize synopsis of master thesis through ppt. presentation.						

SOA/FCMC/599A - RESEARCH REVIEW

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical/ Term Paper	Total
Master's Seminar	SOA/FCMC/599A	0+7	-	-	100	100(7)
<ul style="list-style-type: none">Mid-term progress will be presented by each student by ppt. presentation.Master thesis review work will be presented by each student.						

SEMESTER IV

SOA/FEMC/513 – TREE SEED TECHNOLOGY

I - Title	II - Code	III - Credit Hours	Theory	Internal	Practical	Total
Master's Seminar	SOA/FEMC/591	2+1	60	20	20	100(3)

IV - Aim of the Courses

To impart knowledge and develop understanding about tree seed development, harvesting, processing, storage, dormancy, germination of tropical, sub-tropical and temperate species, their testing and certification.

V. Theory

Unit I

Trends and development in tropical, sub-tropical and temperate forestry and their influence on seed demand. Seed problems, limiting factors in tree propagation and afforestation.

Unit II

Ecological fruit and seed types – seasonality and periodicity of flowering and fruiting. Seed structure and chemical composition development and maturation germination breakdown of storage products endogenous hormonal regulation effect of stimulators and inhibitors. Dormancy its causes and breakage specific problems of seeds of woody plants.

Unit III

Determining optimal harvest maturity indices. Methods of seed collection and processing. Storage methods – loss of viability during storage. Dormancy and pretreatment and seed testing techniques.

Unit IV

Quality seed production technologies – Seed stand/ seed production area, pollen management in seed orchards. Seed transfer guidelines. Seed certification and legislation.

Unit V

Factors affecting seed longevity. Pre-storage treatment. Physiological change during ageing. Viability and vigor. Storage of orthodox, recalcitrant and pre-storage intermediate seeds, Fumigation and seed treatment.

Unit VI

Seed fortification. Seed pelleting.

VI. Practical

- Identification of forest seed;

- Seed sampling, Seed quality testing- purity, viability and germination;
- Collection and processing of seeds/ fruit. Different storage methods;
- Pretreatment of seed;
- Seed fortification;
- Seed pelleting.

VII. Suggested Reading

- Dutta M and Saini GC. 2009. Advances in Forestry Research in India, Vol. XXX. Forest Tree Improvement and Seed Technology. International Book Distributors.
- Khullar P, Thapliyal RC, Beniwal BS, Vakshasya and Sharma A. 1991. Forest Seeds. ICFRE.
- Lars H Schmidt. 2000. Guide to Handling of Tropical and Subtropical Forest Seeds. Danida Forest Seed Centre. Mema NP. 1989. Principles of Seed Certification and Testing. Allied Publ. Negi SS. 2008. Forest Tree Seeds. International Book Distributors
- Ram Prasad and Kandya RK. 1992. Handling of Forestry Seeds in India. Associated Publ.
- Vanangamudi K. 2007. Advances in Seed Science and Technology, Volume IV. Agrobios (India).
- Vanangamudi K. 2013. Advances in Seed Science and Technology, Volume III. Agrobios (India).
- William RL. 1985. A Guide to Forest Seed Handling with Reference to the Tropics. FAO.
- Zobel B and Talbert J. 1984. Applied Forest Tree Improvement. John Wiley & Sons.

SOA/FE/599B – MASTER’S RESEARCH

I - Title	II – Code	III - Credit Hours	Theory	Internal	Practical/ Term Paper	Total
Master’s Research	SOA/FE/599B	0+23	-	-	100(23)	100(23)
Evaluation of the master thesis shall be as follows:						
1. Periodical presentation						20 Marks
2. Viva-Voce						20 Marks
3. Thesis evaluation						60 Marks
Evaluation of the thesis shall be done by one external and one internal examiner.						