

## (VII) M. Sc. (Forestry) Forest Biology and Tree Improvement

### Major Courses

Course Code	Course Title	Credit Hrs.
	<b>Semester I</b>	
FBT-511 *	Applied Forest Tree Improvement	2+1
FBT-512	Tree Seed Orchards	2+1
FBT-513	Forest Genetic Diversity and Conservation	3+0
FBT-514	Clonal Forestry	2+0
FBT-515	Physiology of Woody Plants	2+1
FBT-516	Tree Seed Technology	2+1
	<b>Semester II</b>	
FBT-521*	Quantitative Genetics in Forest Tree Breeding	2+1
FBT-522*	Biotechnology in Forestry	2+1
FBT-523	Forest Ecology and Biodiversity Management	2+1
FBT-524	Reproductive Biology of Forest Trees	2+1
FBT-525	Forest Ecophysiology	2+1
FBT-526	Breeding for Insect Pest and Disease Resistance in Trees	2+1
	<b>Semester III</b>	
FBT-531*	Breeding Methods in Forest Trees	2+1
FBT-591	Master's Seminar	1(1+0)
	<b>Semester IV</b>	
FBT-599	Master's Research	0+30

\* Core and compulsory courses

### Syllabus of Major courses of Forest Biology and Tree Improvement

#### FBT-511 Applied Forest Tree Improvement (2+1)

##### 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. Attractants 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.

### **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.
- 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.

## **FBT-512 Tree Seed Orchards (2+1)**

### **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.
- 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.

#### **FBT-513 Forest Genetic Diversity and Conservation (3+0)**

##### **THEORY**

##### **UNIT I**

Phytodiversity-concept, levels ecosystem. Genetic diversity and differentiation definition, characteristics and importance for tree breeding. Genetic erosion. Techniques to assess genetic diversity. Analysis of karyotypic variation.

##### **UNIT II**

Molecular approaches for assessing genetic diversity. Inventory and monitoring biodiversity: sampling strategies for genetic diversity assessments sufficiency of sampling procedures, neutral allele model and optimal allocation of sampling efforts.

##### **UNIT III**

Methods of sampling of genetic diversity. Factors influencing levels of genetic diversity in woody plant species. Conservation of genetic diversity Conservation biology and invasive species.

##### **UNIT IV**

Laws and policies. Methods for maintenance of conservation: gene banks, arboreta, botanical gardens, breeding populations as repositories of gene conservation. Rare, threatened biodiversity, endangered and endemic plants.

##### **UNIT V**

Techniques for survey and assessment of endangered plants. Rarity patterns and endemism. Concept of island biogeography. Managing corridors and natural habitat fragments.

##### **UNIT VI**

Monitoring and recovery plans for endangered plants. Plant community reserves. Managing wild flora tourism impacts and eco tourism and urban forestry of rare/ exotic plants. Implications of rarity.

#### **VI. SUGGESTED READING**

- Engles JMM, Rao VR Brown AHD and Jackson MT. 2002. Managing Plant Genetic Diversity. CABI and IPGRI.
- FAO. 1985. Forest Tree Improvement, FAO Publication.
- Fins L, Friedman ST and Brotschol JV. 1992. Handbook of Quantitative Forest Genetics. Kluwer.
- IPGRI. 2004. Forest Genetic Resources Conservation and Management. Vol. 1, 2 and 3.
- Khosla PK. 1981. Advances in Forest Genetics. Ambika Publ., New Delhi.
- Mandal AK and Gibson GL. (Eds.). 1997. Forest Genetics and Tree Breeding. CBS.
- 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 and Sons

#### **FBT-514 Clonal Forestry (2+0)**

## **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

## **FBT-515 Physiology of Woody Plants (2+1)**

### **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, anti transpirants.

#### **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. N<sub>2</sub> 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 C<sub>3</sub> and C<sub>4</sub> 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

- Luttge 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-Verlag, Berlin.
- Noggle RG. and Fritz G.J. 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.

## **FBT-516 Tree Seed Technology (2+1)**

### **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).

## **FBT-521 Quantitative Genetics in Forest Tree Breeding (2+1)**

### **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. Forest Service United States Department of Agriculture Washington, D. C.
- Singh RK and Chaudhary BD. 1985. Biometrical Methods in Quantitative genetical Analysis. Kalyani Publishers, New Delhi.

## **FBT-522 Biotechnology in Forestry (2+1)**

### **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; Tissue culture techniques for production of superior planting materials. 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. ; Tissue culture techniques for production of superior planting materials.

#### **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;
- Micro propagation: 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;
- Isolation of DNA
- Diversity analysis using Molecular Markers
- Study of PCR techniques
- Tissue culture techniques for production of superior planting materials
- 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 Verleg, New York.
- Bonga JM and Durjan J. 1987. Cell and Tissue Culture in Forestry Vol. I & II. Martinus NijostPublishers, Dordrecht.
- Hainer R. 1996. Biotechnology in Forest Tree Improvement. (FAO Bulletin 1994) International Book Distributors. Dehra Dun.
- Muchugi A, Kdu C, Kindt R, Kipruto H, Lemurt S, Olale K, Nyadoi P, Dawson I and JamnadassR. 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.

### **FBT-523 Forest Ecology and Biodiversity Management (2+0)**

#### **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 Burkharts H. 2001. *Forest Measurements*. McGraw-Hill Education.
- Barnes BV, Zak DR, Denton SR and Spurrs 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.

### **FBT-524 Reproductive Biology of Forest Trees (2+1)**

#### **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**

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**

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

### **V. 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.

### **VI. 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>).

## **FBT-525 Forest Ecophysiology (2+1)**

### **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 evapotranspiration 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 evapotranspiration;
- Measurement of radiation in different types of forest and agroforestry systems.

#### **VII. SUGGESTED READING**

- Kozłowski 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
- Lutge U. 2008. Physiological Ecology of Tropical Plants. Springer-Verlag, Germany

### **FBT-526 Breeding for Insect Pest and Disease Resistance in Trees (2+1)**

#### **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.

- William M Ciesla. 2010. Forest Entomology-A Global Perspective. Wiley-Blackwell.

### **FBT-531 Breeding Methods in Forest Trees (2+1)**

#### **THEORY**

##### **UNIT I**

Genetic constitution of tree populations, half-sib, full-sib family in trees. Hardy-Weinberg 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.
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- Wright JW. 1962. Genetics of Forest Tree Improvement. Academic Press.
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