

# **COURSE CATALOGUE & SYLLABUS** **(As Per ICAR-BSMA COMMITTEE)**

**FOR**

## **M.Sc. (FORESTRY) FOREST BIOLOGY AND TREE IMPROVEMENT**



**Dept. of Forest Biology, Tree  
Improvement & Wildlife Sciences**

**College of Forestry**

**Sam Higginbottom University of  
Agri., Tech. & Sci. (SHUATS)  
Prayagraj (Allahabad), U.P., India**

## M.Sc. (FORESTRY) FOREST BIOLOGY AND TREE IMPROVEMENT

### Course work

#### 1. Major courses (20credits)

Course Code	Title of the Course	L	T	P	Total Credits	Semester
FBT-501 *	Applied Forest Tree Improvement	2	0	1	3	I
FBT-502	Forest Ecology and Biodiversity Management	2	0	1	3	II
FBT-503*	Breeding Methods in Forest Trees	2	0	1	3	I
FBT-504	Reproductive Biology of Forest Trees	2	0	1	3	II
FBT-505	Tree Seed Orchards	2	0	1	3	I
FBT-506*	Quantitative Genetics in Forest Tree Breeding	2	0	1	3	II
FB- 507	Forest Genetic Diversity and Conservation	3	0	0	3	I
FBT-508*	Biotechnology in Forestry	2	0	1	3	II
FBT-509	Clonal Forestry	2	0	0	2	I
FBT-510	Forest Ecophysiology	2	0	1	3	II
FBT-511	Physiology of Woody Plants	2	0	1	3	I
FBT-512	Breeding for Insect Pest and Disease Resistance in Trees	2	0	1	3	II
FBT-513	Tree Seed Technology	2	0	1	3	I
<b>Total Credits</b>		27	0	11	38	

#### 2. Minor courses (8 credits)

Courses from Silviculture and Agroforestry or Forest Products and Utilization or Natural Resource Management and Environmental Science

#### 3. Supporting courses (6 credits)

Course Code	Title of the Course	L	T	P	Total Credits	Semester
MAS-815*	Experimental Design	2	0	1	3	1
MAS-511	Statistical Methods(Deficiency)	2	0	1	3	1
CSIT-701	Computer Orientation	2	0	1	3	1

#### 4. Common Courses (5 credits)

Course Code	Title of the Course	L	T	P	Total Credits
PGS-501	Library and information Services	0	0	1	1

LNG-502	Technical Writing and Communication skills	0	0	1	1
AEAB-503	Intellectual Property & its management in Agriculture	0	0	1	1
FBT-515	Basic Concept in Laboratory Technique	0	0	1	1
AEAB-505	Agricultural Research, Research Ethics and Rural Development programme	0	0	1	1

#### 5. Seminar (1 credits)

Course Code	Title of the Course	L	T	P	Total Credits	Semester
FBT-591*	Master's Seminar -I	0	0	1	1	II

#### 6. Research (30 credits)

Course Code	Title of the Course	L	T	P	Total Credits
FBT-599	Master's Thesis Research	0	0	30	30

**\*Compulsory Core Courses**

**Course Title: Applied Forest Tree Improvement**

**Course Code: FBT-501**

**Credit Hours: 2+1**

**Aim of the course**

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

**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.

**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.

## 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.

## Theory

Sl. No	Topic	No of Lecture(s)
1	General concept of forest tree breeding, tree improvement and forest genetics	1
2	Reproduction in forest trees – dimorphism, pollination mechanism, pollen dispersal, pollinators, attractants for pollinator	5
3	Variation in trees importance and its causes. Natural variation as a basis for tree improvement. Geographic variations – ecotypes, clines, races and land races	2
4	Plus tree selection for wood quality, disease resistance and agroforestry objectives	2
5	Selective breeding methods- mass, family, within family, family plus within family	2
6	Selection strategies and choice of breeding methods and progress in selective breeding in forest trees	2
7	Progeny and clone testing. Estimating genetic parameters and genetic gain Clonal and breeding values	2
8	Seed orchards – type, functions and importance, Genetic testing mating designs and field designs	2
9	Average performance of half sibs and full sibs, GxE interaction in trees	2
10	Heterosis breeding: inbreeding and hybrid vigour Manifestation and fixation of heterosis. Species and racial hybridization. Indian examples – teak, sal, shisham, eucalypts, acacias, pines and poplars	3
11	Polyploidy, aneuploidy and haploidy in soft and hard wood species. Induction of polyploidy	2
12	Mutation breeding	2
13	Elements of Biotechnology in tree improvement	5
<b>Total</b>		<b>32</b>

<b>Practical</b>		
<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Floral biology, modes of reproduction and modes of pollination in forest trees	2
2	Estimating pollen viability. Controlled pollination and pollen handling	2
3	Manipulation of flowering through hormones	2
4	Identification of ecotypes, races, and land-races in natural forest	1
5	Visit to species, provenance and progeny trials	1
6	Selection of superior phenotypes. Marking of candidate trees, plus trees and elite trees	1
7	Visit to seed orchards	1
8	Comparison of parents and their putative hybrids	1
9	Induction of polyploidy through colchicine treatment	1
10	<i>In-vitro</i> propagation	2
11	Study of molecular markers	2
<b>Total</b>		<b>16</b>

**Course Title : Forest Ecology and Biodiversity Management**

**Course Code : FBT-502**

**Credit Hours : 2+1**

### **Aim of the course**

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

### **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.

## 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.

## 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.

## Theory

Sl. No	Topic	No of Lecture(s)
1	Hierarchy issues in ecology and ecosystem	3
2	Advanced topics in forest ecology including forest population, forest community dynamics, forest community structure and analysis	3
3	Forest productivity, ecology of forest landscapes spatial heterogeneity and ecological succession	3
4	Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserve)	3
5	Climate change, global warming and forests. Green house effect and its consequences	2
6	Ozone depletion. Conservation laws and acts	2
7	Forest genetics resources of India: timber and non timber species	3
8	Survey exploration and sampling strategies Phytogeography and vegetation types of India	2
9	Documentation and evaluation of forests genetical resources (FGR)	2

10	<i>In situ</i> and <i>ex situ</i> conservation of gene resources	3
11	Phytodiversity and its significance to sustainable use. Handling and storage of FGR	3
12	Intellectual property rights	2
13	Quarantine laws and FGR exchange	2
<b>Total</b>		<b>32</b>

### Practical

Sl. No	Topic	No of Lecture(s)
1	Study of forest community structure and its successional status	2
	Estimation of productivity of forest ecosystem	2
2	Study tours to different regions of the state to study forest vegetation	2
3	Collection and preservation of specimen	2
4	Methods of vegetation analysis	2
5	Measurement of biomass and productivity	2
6	Quantification of litter production and decomposition	2
7	Visit to national parks, wildlife sanctuaries, botanical gardens and arboreta	2
<b>Total</b>		<b>16</b>

**Course Title : Breeding Methods in Forest Trees**

**Course Code : FBT-503**

**Credit Hours : 2+1**

### Aim of the course

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

### 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.

## 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.

## 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.

## Theory

Sl. No	Topic	No of Lecture(s)
1	Introduction	1
2	Hardy-Weinberg equilibrium, changes in gene frequency through selection, migration, mutation and population sizes	5
3	Grading system of plus trees in natural stands and plantations regression systems, mother tree selection, subjective evaluation	2
4	Selective breeding methods- mass, family, within family, family plus within family	2
5	Long-term and short-term breeding populations	4
6	Genetic testing programmes – mating designs, Incomplete pedigree designs – open pollinated mating and polycross mating	2
7	Complete designs (nested designs, factorial, single pair mating, full	2

	diallel, half diallel and partial diallel)	
8	Experimental designs in genetic testing	2
9	Marker assisted selection	2
10	Breeding methods for disease resistance	2
11	Breeding methods for water stress	2
12	Breeding methods for pest resistance	2
13	Tree improvement case histories. Breeding strategy for pines and eucalyptus	4
	<b>Total</b>	<b>32</b>

### **Practical**

<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Grading system of plus trees in natural stands, plantation	1
2	Mating designs	1
3	Complete designs – nested designs	2
4	Factorial	4
5	Single pair mating	2
6	Full diallel, Half diallel and Partial diallel	4
7	Incomplete pedigree designs – open pollinated mating and polycross mating	2
	<b>Total</b>	<b>16</b>

**Course Title : Reproductive Biology of Forest Trees**

**Course Code : FBT-504**

**Credit Hours : 2+1**

### **Aim of the course**

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.

### **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 extrafloral 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.

#### 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.

#### 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*.
- CláudiaInês da Silva and Helena Maura TorezanSilingardi. 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>).

#### Theory

Sl. No	Topic	No of Lecture(s)
1	Importance and application of reproductive biology in tree breeding	1
2	Crop characteristics-growth and development (both vegetative and reproduction)	4
3	Floral diversity and pollination. Flower types: Pollination syndromes and their evolution; Plant – pollinator systems, Diversity of pollination syndromes in selected plant families	4
4	Modes of reproduction: sexual, asexual and vegetative and their	5

	breeding systems and sex expression, monoecy, dioecy and its evolution	
5	Environmental effects on sex expression	3
6	Floral biology. Initiation and development. Modes of pollination; self and out-crossing	3
7	Floral attractants and rewards; Biology of floral and extra floral nectarines; Examples of plant insect interactions involving pollination. Floral characteristics of the main pollination syndromes	5
8	Fertilization in hardwood and softwood species	3
9	Seed dispersal and gene flow	4
	<b>Total</b>	<b>32</b>

### **Practical**

<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Sex expression in forest trees	2
2	Measurement of pollen flow in wind-pollinated and insect-pollinated species	3
3	Pollen viability and fertility	2
4	Seed dispersal mechanism	3
5	Study of reproductive biology of Eucalyptus, Pine, Shishum, etc.	3
	<b>Total</b>	<b>16</b>

**Course Title : Tree Seed Orchards**

**Course Code : FBT-505**

**Credit Hours : 2+1**

### **Aim of the course**

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. Ortet 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.

#### 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.

#### 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.

#### Theory

Sl. No	Topic	No of Lecture(s)
1	Importance of genetically improved seed in plantation forestry	1
2	Status of seed production among major plantation species	2
3	Short term supply of superior seed	1
4	Selection and delineation of seed stands, seed production areas, seed zones, seed ecological zones	4
5	Seed orchard: need, evolving seed orchards, containerized seed, hybrid and research seed orchards; first, second and advanced generation seed orchard. Seed orchard genetics: random mating, gamete exchange and parental balance	6
6	Estimation of genetic parameters from seed orchard data. Ortet age and its effect on seed production	3
7	Importance of progeny testing	2
8	Establishment of seed orchards, selection and preparation of orchard	4

9	site, isolation, orchard size, and designs Seed orchard management: rouging, silvicultural practices to increase seed yield. Supplemented mass pollination. Pest and disease management. Seed collection and record keeping, seed orchard registration and documentation	5
10	Importance of seed orchards in gene conservation	2
11	Status of seed production among major plantation species	2
<b>Total</b>		<b>32</b>

### **Practical**

<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Visits and study of seed orchard designs.	2
2	Estimation of overlap in flowering among genotypes.	2
3	Study of inter and intra-clonal variation in floral and seed characters.	2
4	Effect of girdling on flowering.	2
5	Plant growth regulator application for flower induction.	2
6	Pollen viability/ fertility.	1
7	Assessment of pollen dispersal.	2
8	Supplemental mass-pollination.	2
9	Effects of foliar application of fertilizers on seed set.	1
<b>Total</b>		<b>16</b>

**Course Title : Quantitative Genetics in Forest Tree Breeding**

**Course Code : FBT-506**

**Credit Hours : 2+1**

### **Aim of the course**

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

### **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.

#### **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.

#### **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.

#### **Theory**

<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Historical aspects of quantitative genetics	1
2	Genetic variance and its partitioning, models of gene action	3
3	Inheritance of continuously varying characters	2
4	Multiple factor hypothesis (Nilsson-Ehle (1908) and East (1915) experiments	2
5	Mating systems, population structure in random mating	3

6	Hardy Weinberg law, effect of selection, mutation, migration, genetic drift: on genes and genotypic frequency	3
7	Inbreeding, effects of inbreeding in various populations	2
8	Heterosis, causes of heterosis and its utility in various plants	2
9	Significance and estimation of genetic variance components. Heritability, its estimation by various methods and significance	2
10	Natural selection, fundamental theorem of natural selection (Fisher 1930)	2
11	Selection responses. Correlation and its utility. Partitioning of correlation into direct and indirect effects	2
12	Mating designs	3
13	Combining ability, general and specific combining ability and methods of its estimation	2
14	Genotypic $\times$ environment interaction, its significance. Various procedures for the estimation of genotypic x environment interaction	3
<b>Total</b>		<b>32</b>

### Practical

Sl. No	Topic	No of Lecture(s)
1	Polygenic inheritance	2
2	Proof that quantitative characters are inherited in Mendelian fashion	1
3	Estimation of genotypic and phenotypic variance in an experiment through various procedures	2
4	Mating designs and estimation of additive and dominance components of variance components of genetic variance	3
5	Proof of population genetics law	1
6	Calculation of gene and genotypic frequency	1
7	Estimation of heterosis, estimation of heritability (broad sense and narrow sense) by various methods	2
8	Genotypic and phenotypic correlation coefficients, partitioning of correlation into direct and indirect effects	1
9	Estimation of general combining ability and specific combining ability	1
10	Estimation of genotypic x environment interaction	2
<b>Total</b>		<b>16</b>

**Course Title : Forest Genetic Diversity and Conservation**

**Course Code : FBT-507**

**Credit Hours : 3+0**

### Aim of the course

To provide the knowledge about the genetic diversity in forest tree species, their distribution, assess and analysis and methodologies of *in-situ* and *ex-situ* conservation.



## **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.

## **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.

<b>Theory</b>		
<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Phytodiversity-concept, levels ecosystem	2
2	Genetic diversity and differentiation-definition, characteristics and importance for tree breeding	3
3	Genetic erosion. Techniques to assess genetic diversity	3
4	Analysis of karyotypic variation	2
5	Molecular approaches for assessing genetic diversity	3
6	Inventory and monitoring biodiversity	3
7	Sampling strategies for genetic diversity assessments sufficiency of sampling procedures	2
8	Neutral allele model and optimal allocation of sampling efforts	3
9	Methods of sampling of genetic diversity	2
10	Factors influencing levels of genetic diversity in woody plant species	2
11	Conservation of genetic diversity conservation biology and invasive species	2
12	Laws and policies	2
13	Methods for maintenance of conservation: Gene banks, arboreta, botanical gardens, breeding populations as repositories of gene conservation	3
14	Rare, threatened biodiversity, endangered and endemic plants	1
15	Techniques for survey and assessment of endangered plants	3
16	Rarity patterns and endemism	2
17	Concept of island biogeography. Managing corridors and natural habitat fragments	2
18	Monitoring and recovery plans for endangered plants	2
19	Plant community reserves	2
20	Managing wild flora tourism impacts and eco tourism and urban forestry of rare/ exotic plants	2
21	Implications of rarity	2
<b>Total</b>		<b>48</b>

**Course Title : Biotechnology In Forestry**

**Course Code : FBT-508**

**Credit Hours : 2+1**

**Aim of the course**

To impart knowledge about different aspects of biotechnology in forestry

## **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.

## **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).

## **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*. MartinusNijost 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, Englewood, 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.

<b>Theory</b>		
<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Prospects of micro-propagation in forestry	1
2	Techniques, procedures and problems in micro propagation – case studies	2
3	Protocols for micro-propagation, choice of explants for micro-propagation preconditioning of explants, surface sterilization, nutritional media – other environmental factors controlling micro-propagation	2
4	Micro propagation of juvenile material – Micro propagation of mature trees, <i>In-vitro</i> propagation of plants with low sexual reproduction rates, miscellaneous application	2
5	Initiation and maintenance of callus, organogenesis and somatic embryogenesis, factors influencing somatic embryogenesis-applications in forestry, Somatic seeds, encapsulation techniques.	3
6	Somaclonal variation, genetic and epigenetic variation, exploitation in forestry	2
7	Cell suspension cultures, anther and pollen cultures, triploids through endosperm culture, embryo culture	2
8	Monoploid production by chromosome elimination	1
9	Applications of <i>In-vitro</i> fertilization	1
10	Isolation, purification and culture of protoplasts, protoplast fusion and somatic hybridization	3
11	Cryopreservation, storage of plant genetic resources.	1
12	Production of secondary metabolites by cell cultures	2
13	Meristem culture – virus free plants	1
14	Genetic engineering – application in forestry, Isozymes, Restriction Fragment Length Polymorphisms (RFLPs), Randomly Amplified Polymorphic DNAs (RAPDs) and Microsatellites	3
15	Genetic fingerprinting, marker assisted selection. Different PCR techniques: their characteristics, with advantages and disadvantages.	3
16	Quantification of genetic diversity, genotype verification and delineation	2
17	Introduction of genes, Promoters and marker genes. Disease	2

resistance, herbicide tolerance and tolerance to salt and other stresses

**Total**

33

**Practical**

<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Introduction to tissue culture lab	1
2	Micropropagation: Aseptic techniques, Preparation of culture media, Formulation of different culture media, explants inoculation, subculture and <i>in-vitro</i> rooting	4
3	Induction and maintenance of callus, regeneration of plants from callus	
4	Cell suspension culture	2
5	Anther and pollen culture	2
6	Isolation and culture of protoplasts	2
7	Study of PCR techniques used in tree improvement. Testing of clonal fidelity through molecular markers	3
8	Application of GENALEX 'bolt on' for Excel, Arlequin, PopGene and FSTAT for Wright's F-statistics and Analysis of Molecular Variance (AMOVA)	2
	<b>Total</b>	16

**Course Title : Clonal Forestry**

**Course Code : FBT-509**

**Credit Hours : 2+0**

**Aim of the course**

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

**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 maintenance, 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.

#### 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

#### Theory

Sl. No	Topic	No of Lecture(s)
1	Introduction to clonal forestry; History of clonal forestry	2
2	Clonal planting, strategies for clonal forestry for higher	4
3	Productive potential	2
4	Juvenility and Maturation, rejuvenation and maintainance, regulation of phase changes, markers of phase changes	3
5	Breeding strategies using vegetative propagation- selection and breeding for extreme genotypes	4
6	Physiological research for higher productivity of clonal forestry	3
7	Field design, testing and evaluation of clones	3
8	Genetic gains from breeding with clonal option. Clonal conservation approaches- management of populations for genetic diversity and gain	4
9	Biotechnological approaches for clonal forestry plant tissue culture- micropropagation	3
10	Rejuvenation of tissues from mature trees	2
11	Testing of clonal fidelity using molecular markers	2
<b>Total</b>		<b>33</b>

**Course Title : Forest Ecophysiology**

**Course Code : FBT-510**

**Credit Hours : 2+1**

#### Aim of the course

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

## **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.

## **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.

## **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
- 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.

### Theory

Sl. No	Topic	No of Lecture(s)
1	Forest environment interactions, forest ecosystems, geographic and climatic factors. Environmental factors influencing forest growth and productivity. Sun and shade plants	3
2	Influence of temperature, water stress and nutrient availability and disturbance in the forest on tree growth and forest productivity	3
3	Dynamics of forest ecosystems, energy, productivity and biomass. Decomposition and nutrient cycling	3
4	Stand structure and micro-climate, energy relationships, Canopy energy balance. Partitioning absorbed energy	3
5	Radiation penetration into and absorption by canopies. Air temperature and humidity in forests. Turbulent transfer process above forests	3
6	Transpiration and evapotranspiration from forest canopies, Estimation of ET	3
7	Stress – avoidance and tolerance mechanisms	2
8	Drought stress	3
9	Temperature stress, low temperature stress, physiology of resistance to frost	3
10	Heat stress, heat injury, heat avoidance and tolerance mechanism	3
11	Radiation stress – mechanism of shade tolerance	1
12	Water logging, physiology of resistance to water logging	1
13	Salt and ion stress	2
<b>Total</b>		<b>33</b>

### Practical

Sl. No	Topic	No of Lecture(s)
1	Morphological, anatomical and physiological variations between sun and shade plant	3
2	Estimation of leaf area, LAI	2
3	Estimation of biomass production of trees of different species	3
4	Estimation of microclimatic elements as influenced by stand structure	3
5	Estimation of evapotranspiration	2
6	Measurement of radiation in different types of forest and agroforestry	3
<b>Total</b>		<b>16</b>



**Course Title : Physiology of Woody Plants**

**Course Code : FBT-511**

**Credit Hours : 2+1**

**Aim of the course**

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

**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. N<sub>2</sub> fixation, physical and biological. Nitrogen assimilation, Amino acid and protein synthesis.

**Unit X**

Fat metabolism. Carbohydrate metabolism.

**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.

### 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-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.

### Theory

Sl. No	Topic	No of Lecture(s)
1	Introduction, Tree physiology, growth, phases of growth, growth curve factors affecting growth, wood formation	3
2	Plant cell as a structural and functional unit. Organization	2
3	Structure of leaves, stem wood, bark and roots in trees. Functions and process in plant growth and development	4
4	Photosynthesis, structure of photosynthetic tissues and organs, enzyme, energetics and factors influencing photosynthesis. Photorespiration, its mechanisms and significance, factors affecting photorespiration	4
5	Respiration, mechanisms, enzymes, energetics and factors influencing respiration. Respiratory quotient	3
6	Water relations of trees, absorption, ascent of sap. Translocation of solutes – Phloem loading and phloem transport. Transpiration, Mechanisms and factors influencing,regulating transpiration, antitranspirants	4

8	Mineral nutrition, Mineral salt absorption and translocation, deficiency and toxicity of mineral nutrients. Diagnosis of mineral deficiency	3
9	The enzymes, nomenclature and classification, structure and composition – Mode of action. Phytohormones – auxins, GA, cytokinins, ABA, ethylene biosynthesis and biochemical activity of Plant hormones. Synthetic plant growth regulators. Growth retardants	3
10	Nitrogen fixing trees, Nitrogen metabolism. N <sub>2</sub> fixation, physical and biological. Nitrogen assimilation, Amino acid and protein synthesis.	3
11	Fat metabolism. Carbohydrate metabolism	3
<b>Total</b>		<b>32</b>

### Practical

Sl. No	Topic	No of Lecture(s)
1	Preparation of growth curves of different tree seedlings	2
2	Study of structure of leaves. Observing structure of plant cells and leaves in C3 and C4 species	2
3	Measurement of photosynthesis	2
4	Studying stomata in different tree species and working out stomatal frequency and size	1
5	Estimation of transpiration rates in different trees	2
6	Isolation and estimation of chlorophyll	1
7	Observing xylem vessel size variation in tree species	1
8	Estimation of plant water status by different methods	3
9	Nutrient deficiency symptoms in tree seedlings	2
<b>Total</b>		<b>16</b>

**Course Title : Breeding for Insect Pest and Disease Resistance in Trees**

**Course Code : FBT-512**

**Credit Hours : 2+1**

#### **Aim of the course**

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

#### **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. Defence mechanisms against insects. Factors affecting tree pest resistance. Breeding for insect resistance.

### 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.

### 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.

### Theory

Sl. No	Topic	No of Lecture(s)
1	Need for disease resistance in forest trees	1
2	Process of infection, variability in plant pathogens	3
3	Inheritance of resistance	3
4	Disease resistance mechanisms in trees	2
5	Clonal resistance	1
6	Disease resistance breeding techniques	3
7	Types of resistance techniques of isolating resistant genes	3
8	Developing disease resistant transgenic plants	2
9	History and importance of insect pest resistance	1
10	Types and mechanism of resistance	2
11	Insect-tree relationships	3
12	Basis of resistance: Induced resistance and acquired resistance.	4

	Defence mechanisms against insects	
13	Factors affecting tree pest resistance	2
14	Breeding for insect resistance	2
	<b>Total</b>	<b>32</b>

### **Practical**

<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Disease progression in relation to resistance	3
2	Disease resistance in clonal plantations and seed orchards	2
3	Hypersensitivity and its mechanisms	2
4	Disease resistance screening	3
5	Screening for insect pest resistance	2
6	Chemical and morphological characterization of susceptible/ resistance tree species	2
7	Defence strategies of woody plants	2
	<b>Total</b>	<b>16</b>

**Course Title : Tree Seed Technology**

**Course Code : FBT 513**

**Credit Hours : 2+1**

### **Aim of the course**

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.

### **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.

## 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.

## 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.
- KhullarP, 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.

## Theory

Sl. No	Topic	No of Lecture(s)
1	Trends in seed demand. Seed problems, limiting factors in tree propagation and afforestation	2
2	Ecological fruit and seed types – seasonality and periodicity of flowering and fruiting	3
3	Seed structure and chemical composition – development and maturation	2
4	Germination – breakdown of storage products endogenous hormonal regulation	2
5	Effect of stimulators and inhibitors dormancy – its causes and breakage	2
6	Determining optimal harvest maturity indices	2

7	Methods of seed collection and processing, storage methods loss of viability during storage	2
8	Dormancy and pre-treatment	2
9	Seed testing techniques	2
10	Quality seed production technologies seed stand/ seed production area	2
11	Pollen management in seed orchards	2
12	Seed transfer guidelines	2
13	Seed certification and legislation	2
14	Factors affecting seed longevity. Pre-storage treatment. Physiological change during ageing. Viability and vigor	3
15	Storage of orthodox, recalcitrant and pre-storage intermediate seeds, Fumigation and seed treatment	2
<b>Total</b>		<b>32</b>

### **Practical**

<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Identification of forest seed	1
2	Collection and processing of seeds/ fruit, different storage methods	2
3	Seed sampling. Seed quality testing- purity, viability and germination	7
4	Pretreatment of seed	2
5	Seed fortification	2
6	Seed pelleting	2
<b>Total</b>		<b>16</b>

**Course Title : Experimental Designs**

**Course Code : MAS- 815**

**Credit Hours : 2+1**

### **Theory**

Analysis of variance- Definition and assumptions, one way classification, two way classification. Sampling Techniques, Simple random sampling, stratified random sampling, systematic sampling. Design Experiments- Randomized Block design, Latin Square design, Factorial design ( $2^2$ ,  $2^3$ ,  $3^2$ ,  $3^3$  factorials), Some P x Q experiments, Split Plot Experiments. Balanced Incomplete Block design.

### **Practical**

Analysis of variance, Randomized Block Design.

### **Suggested Readings**

- Ostle, B. and. Mensing, R.W. 1964. Statistics in Research.
- Goulden, C.H. 2007. Method of Statistical Analysis.

- Snedecor, G.W. and Cochran, W.G. 1989. Statistical Methods.
- Steel, R.G. and Torrie, J.H. 1980. Principles and Procedures of Statistics (with special reference to Biological Sciences).
- Rangaswamy, R. 2010. A Text Book of Agricultural Statistics.
- Chandel, S.R.S. 2014. A Text Book of Agricultural Statistics.
- Cochran, W.G. and Cox, G.M. 1992. Experimental Designs.

### Theory

Sl. No	Topic	No of Lecture(s)
1	Analysis of variance	2
2	Definition and assumptions	2
3	One way classification	2
4	Two way classification	2
5	Sampling Techniques	2
6	Simple random sampling	2
7	Stratified random sampling	2
8	Systematic sampling	2
9	Design Experiments	2
10	Randomized Block design	2
11	Latin Square design	2
12	Factorial design ( $2^2$ , $2^3$ , $3^2$ , $3^3$ factorials)	3
13	Some P x Q experiments	3
14	Split Plot Experiments	2
	Balanced Incomplete Block design	2
	<b>Total</b>	<b>32</b>

### Practical

Sl. No	Topic	No of Practical(s)
1	Analysis of variance	6
2	Randomized Block Design	10
	<b>Total</b>	<b>16</b>



**Course Title : Statistical Methods**

**Course Code : MAS- 511**

**Credit Hours : 2+1**

### **Theory**

Statistical Methods- Measures of Skewness and Kurtosis, standard error of mean, Coefficient of variation. Theory of Probability- Definitions, Additions and Multiplication rules of Probability, Conditional Probability. Probability distributions- Normal, Binomial and Poisson distributions. Correlation and Regression- Simple correlation, Rank correlation, Regression Coefficient, Multiple and Partial Correlation, Regression lines between two variables, Multiple Regression. Tests of Significance-  $X^2$  - test, t - test one sample, two sample t - tests, paired t-test, F - test, Fisher's 2- transformation.

### **Practical**

Coefficient of variation, SE of mean, Skewness and Kurtosis. Fitting of Normal, Binomial and Poisson distribution. Simple Correlation, Multiple and Partial Correlation with three variables only. Regression lines between two variables.  $X^2$ , t and F- tests.

### **Suggested Readings**

- Ostle, B. and Mensing, R.W. 1964. Statistics in Research.
- Goulden, C.H. 2007. Method of Statistical Analysis.
- Snedecor, G.W. and Cochran, W.G. 1989. Statistical Methods.
- Steel, R.G. and Torrie, J.H. 1980. Principles and Procedures of Statistics (with special reference to Biological Sciences).
- Rangaswamy, R. 2010. A Text Book of Agricultural Statistics.
- Chandel, S.R.S. 2014. A Text Book of Agricultural Statistics.
- Cochran, W.G. and Cox, G.M. 1992. Experimental Designs.

### **Theory**

<b>Sl. No</b>	<b>Topic</b>	<b>No of Lecture(s)</b>
1	Statistical Methods: Measures of Skewness and Kurtosis	1
2	Standard error of mean	1
3	Coefficient of variation	1
4	Theory of Probability- Definitions	1
5	Additions and Multiplication rules of Probability	2
6	Conditional Probability	2
7	Probability distributions: Normal, Binomial and Poisson distributions	2
8	Correlation and Regression, Simple correlation	2
9	Correlation and Regression, Simple correlation	2

10	Rank correlation	2
11	Regression Coefficient	2
12	Multiple and Partial Correlation	1
13	Regression lines between two variables	1
14	Multiple Regression	2
15	Tests of Significance- $X^2$ - test	2
16	t- test one sample	2
17	Two sample t- tests	2
18	Paired t-test, F- test	2
19	Fisher's 2- transformation	2
	<b>Total</b>	<b>32</b>

### Practical

Sl. No	Topic	No of Practical(s)
1	Coefficient of variation	2
2	SE of mean	1
3	Skewness and Kurtosis	2
4	Fitting of Normal	2
5	Binomial and Poisson distribution	1
6	Simple Correlation	2
7	Multiple and Partial Correlation with three variables only	2
8	Regression lines between two variables	2
9	$X^2$ , t and F- tests	2
	<b>Total</b>	<b>16</b>

**Course Title : Computer Orientation**

**Course Code : CSIT-701**

**Credit Hours : 2+1**

### Theory

Information Concepts , Data and Information, Information System- Application, Elements, types, Computers basics- Definition, Characteristics & Application of Computers, Computer Hardware- I/O devices, Memory, CPU, Software Concepts, Operating System- DOS, Windows, Application Software- MS Word, MS Excel, MS Access, MS Power Point, Adobe Reader, Computer Programming-Algorithm & Flowchart, Introduction to 'C' Language , History, Input & Output Statements, Variables & Constants, Expressions & Operators, Control Statements, Branching Statements (if, if-else, Nested if), Looping Statements (while, do-while, for), Functions & Arrays, Internet Concepts & Search Engine, Application of statistical packages.

## Practical

Demo session on computer & its components, I/O devices, Memory, CPU, MS DOS-Internal DOS Command- md, cd, dir, time, del, type, edit, copy, exit, path, prompt, ren, ver.

External DOS Commands- attrib, backup, chkdisk, diskcomp, diskcopy, doskey, format, label, xcopy, move, tree, undelete, Windows- Login, Desktop, Icons & Folders, Taskbar, Changing Desktop properties, My computer, My Network places, Recycle bin, My Documents, Control panel, Application Software- MS Word- Getting familiar with various tool bars. Tables and Columns, Mail merge. MS Excel- Working with Spreadsheets, Mathematical & Statistical functions, Generating Charts, Creating Macros. MS Access- database table, forms, reports MS Power Point- Designing slides, Adding animation tools to slides, C programming- Programs illustrating use of print f () and scan f () statements, practicing with decision making statements like IF, IF-ELSE, Nested IF,ELSE-IF, Ladder, Switch, Goto, Working with loops, Illustration of Arrays, Designing programs to demonstrate concept of functions, Internet- Website, website, browser, URL, Surfing, Searching, creating mail accounts. A glance over statistical packages like SPSS, MATLAB etc.

## Suggested Readings

- Dixit, J. B. 2006. Fundamentals of Computers & programming in C, Laxmi Publications (P) Ltd.
- Kanetikar, Y. 2016. Let us C, BPH Publications.
- Balaguruswamy, E. 1992. ANSI C, TMH.

## Theory

Sl. No	Topic	No of Lectures
1	Information Concepts	2
2	Data and Information	2
3	Information System: Application , Elements, types	1
4	Computers basics- Definition, Characteristics & Application of Computers	1
5	Computer Hardware: I/O devices, Memory, CPU	1
6	Software Concepts	2
7	Operating System- DOS	2
8	Windows	2
9	Application Software - MS Word, MS Excel, MS Access, MS Power Point, Adobe Reader	3
10	Computer Programming-Algorithm & Flowchart	2
11	Introduction to 'C' Language , History	2
12	Input & Output Statements	1
13	Variables & Constants	1
14	Expressions & Operators	1
15	Control Statements	1
16	Branching Statements (if, if-else, Nested if)	1

17	Looping Statements (while, do-while, for)	1
18	Functions & Arrays	2
19	Internet Concepts & Search Engine	2
20	Application of statistical packages	2
	<b>Total</b>	<b>32</b>

### Practical

Sl. No	Topic	No of Practical(s)
1	Demo session on computer & its components, I/O devices, Memory, CPU	1
2	MS DOS: Internal DOS Command- md, cd, dir, time, del, type, edit, copy, exit, path, prompt, rem, renver	1
3	External DOS Commands- attrib, backup, chkdsk, diskcomp, diskcopy, doskey, format, label, xcopy, move, tree, undelete	1
4	Windows- Login, Desktop, Icons & Folders, Taskber, Changing Desktop properties, My computer,	1
5	My Network places, Recycle bin, My Documents, Control panel	2
6	Application Software- MS Word- Getting familiar with various tool bars, Tables and Columns, Mail merge	1
7	MS Excel: Working with Spreadsheets, Mathematical & Statistical functions, Generating Charts, Creating Macros	1
8	MS Access: database table, forms, reports	1
9	MS Power Point: Designing slides, Adding animation tools to slides	1
	C programming- Programs illustrating use of print f () and scan f () statements, practicing with decision making statements like IF, IF-ELSE, Nested IF, ELSE-IF, Ladder, Switch, Goto	2
10	Working with loops, Illustration of Arrays, Designing programs to demonstrate concept of functions	2
11	Internet: Website, website, browser, URL, Surfing, Searching, creating mail accounts	1
12	A glance over statistical packages like SPSS, MATLAB etc	1
	<b>Total</b>	<b>16</b>

## **NON CREDIT COURSE CONTENTS**

**Course Title : Library and Information Services**

**Course Code : PGS- 501**

**Credit Hours : 0+1**

### **Objective**

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

### **Practical**

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

### **Practical**

<b>Sl. No</b>	<b>Topic</b>	<b>No of Practical(s)</b>
1	Introduction to library and its services	1
2	Role of libraries in education, research and technology transfer	1
3	Classification systems and organization of library	1
4	Sources of information- Primary Sources, Secondary Sources and Tertiary Sources	2
5	Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.)	3
6	Tracing information from reference sources	1
7	Literature survey	1
8	Citation techniques/ Preparation of bibliography	1
9	Use of CD-ROM Databases	1
	Online Public Access Catalogue and other computerized library services	2
10	Use of Internet including search engines and its resources	1
11	e-resources access methods	1
	<b>Total</b>	<b>16</b>

**Course Title : Technical Writing and Communication Skills**

**Course Code : PGS- 502**

**Credit Hours : 0+1**

### **Objective**

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

### **Practical**

Technical Writing- Various forms of scientific writings, thesis, 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, precise, citations etc., commonly used abbreviations in the thesis 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**

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

## Practical

Sl. No	Topic	No of Practical(s)
1	Technical Writing- Various forms of scientific writings thesis, technical papers, reviews, manuals, etc	3
2	Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion)	2
3	Writing of abstracts, summaries, precise, citations etc	1
4	commonly used abbreviations in the thesis and research communications	1
5	illustrations, photographs and drawings with suitable captions, pagination, numbering of tables and illustrations, writing of numbers and dates in scientific write-ups	1
6	Editing and Proof-reading, Writing of a review article	1
7	Communication Skills- Grammar (Tenses, parts of speech, clauses, punctuation marks	2
8	Concord, Collocation, Phonetic symbols and transcription, Accentual pattern	1
9	Weak forms in connected speech, Participation in group discussion	2
	Facing an interview, presentation of scientific papers	2
	<b>Total</b>	<b>16</b>

**Course Title : Intellectual Property & Its Management in Agriculture**

**Course Code : AEAB-503**

**Credit Hours : 0+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.

### Practical

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 bio-diversity 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

- Erbisch, F.H. and Maredia, K. 1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
- Ganguli, P. 2001. Intellectual Property Rights; Unleashing Knowledge Economy. McGraw-Hill.
- Intellectual Property Rights; Key to New Wealth Generation. 2001. NRDC& Aesthetic Technologies.
- Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
- Rothschild, M. and Scott, N. (Ed.) 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
- 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, National Biological Diversity Act, 2003.

### Practical

Sl. No	Topic	No of Practical(s)
1	Historical perspectives and need for the introduction of Intellectual Property Right regime	1
2	TRIPs and various provisions in TRIPs Agreement	2
3	Intellectual Property and Intellectual Property Rights (IPR)	1
4	Benefits of securing IPRs	1
5	Indian Legislations for the protection of various types of intellectual properties	1
6	Fundamentals of patents, copyrights geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio-diversity protection	2
7	Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection	2
8	National Biodiversity protection initiatives, convention on Biological Diversity	1
9	International Treaty on Plant Genetic Resources for Food and Agriculture	1



10	Licensing of technologies, Material transfer agreements	2
11	Research collaboration Agreement, License Agreement	2
<b>Total</b>		<b>16</b>

**Course Title : Basic Concepts in Laboratory Techniques**

**Course Code : SAF-515**

**Credit Hours : 0+1**

### **Objective**

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

### **Practical**

Safety measures while in Lab, Handling of chemical substances, Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes 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, Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-wave, incubators, sand-bath, water-bath. Preparation of media and method of sterilization. Seed viability testing, testing of pollen viability. Tissue culture of plants and trees. Description of flowering plants in relation to utilization of different parts. Study about Haga altimeter, Ravi altimeter, Bark gauge, Preservation and seasoning unit, Caliper, Oven, and their application.

### **Suggested Readings**

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

### **Practical**

<b>Sl. No</b>	<b>Topic</b>	<b>No of Practical(s)</b>
1	Safety measures while in Lab, Handling of chemical substances, Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes washing, drying and sterilization of glassware, Drying of solvents/chemicals	02
2	Weighing and preparation of solutions of different strengths and their dilution, Handling techniques of solutions	02
3	Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-wave, incubators, sand-bath, water-bath	02
4	Preparation of media and method of sterilization	01
5	Seed viability testing, testing of pollen viability	01

6	Tissue culture of plants and trees	02
7	Description of flowering plants in relation to utilization of different parts	01
8	Study about Haga altimeter, Ravi altimeter, Bark gauge	02
9	Preservation and seasoning unit, Caliper, Oven, and their application	03
<b>Total</b>		<b>16</b>

**Course Title : Agricultural Research, Research Ethics and Rural Development**

**Course Code : AEAB-505**

**Credit Hours : 0+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.

### **Practical**

#### **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 Centers (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 Organizations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

### **Suggested Readings**

- Bhalla, G.S. and Singh, G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
- Punia, M.S. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.
- Rao, B.S.V. 2007. Rural Development Strategies and Role of Institutions Issues, Innovations and Initiatives. Mittal Pub.
- Singh, K. 1999. Rural Development-Principles, Policies and Management. Sage Pub.

## Practical

Sl. No	Topic	No of Practical(s)
1	History of agriculture in brief, Global agricultural research system-need, scope, opportunities, Role in promoting food security, reducing poverty and protecting the environment	2
2	National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions, Consultative Group on International Agricultural Research (CGIAR), International Agricultural Research Centers (IARC), partnership with NARS, role as a partner in the global agricultural research system	2
3	strengthening capacities at national and regional levels, International fellowships for scientific mobility	1
4	Research ethics- research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics	2
5	Concept and connotations of rural development, rural development policies and strategies	1
6	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	3
7	Voluntary Agencies/Non-Governmental Organizations	1
8	Critical evaluation of rural development policies and programmes	2
9	Constraints in implementation of rural policies and programmes	2
	<b>Total</b>	<b>16</b>
<b>FBT-591</b>	<b>MASTER'S SEMINAR</b>	<b>0+1</b>
<b>FBT-599</b>	<b>MASTER'S RESEARCH</b>	<b>0+30</b>