DEPARTMENT OF FORESTRY

Nagaland University

(A Central University established by an Act of Parliament No. 35 of 1989)

Hqrs: Lumami, Dist. Zunheboto, Nagaland – 798627

Website: www.nagalanduniversity.ac.in

Detailed Course Structure for 4 Year B.Sc. Forestry (Hons)

Subject Code	Title of the Course	Credit	Practical	Theory Marks		Total
				Int	Ext	
Ist Semester						
FSUGC1	Forest Botany	4 (3+1)	25	30	45	100
FSUGC2	Theory and Practices of Silviculture	4 (3+1)	25	30	45	100
	Total	**08**				**200**
IInd Semester						
FSUGC3	Principles of Plant Physiology	4 (3+1)	25	30	45	100
FSUGC4	Introduction to Forest Mensuration	4 (3+1)	25	30	45	100
	Total	**08**				**200**
Students can exit after 1 year with 40 credits awarded UG Certificate in Forestry						
IIIrd Semester						
FSUGC5	Forest Pathology and Disease Management	4 (3+1)	25	30	45	100
FSUGC6	Tissue Culture and Tree Breeding	4 (3+1)	25	30	45	100
	Total	**08**				**200**
IVth Semester						
FSUGC7	Wildlife and Conservation Biology	4 (3+1)	25	30	45	100
FSUGC8	Biofertilizer and Mushroom Technology	4 (3+1)	25	30	45	100
	Total	**08**				**200**
Students can exit after 2 years with 80 credits awarded UG Diploma in Forestry						
Vth Semester						
FSUGC9	Principles of Agroforestry	4 (3+1)	25	30	45	100
FSUGC10	Clonal Forestry	4 (3+1)	25	30	45	100
FSUGC11	Dendrology	4(3+1)	25	30	45	100
	Total	**12**				**300**
VIth Semester						
FSUGC12	Forest Biotechnology	4 (3+1)	25	30	45	100
FSUGC13	Wood Science	4 (3+1)	25	30	45	100
FSUGC14	Soil Biology and Fertility	4 (3+1)	25	30	45	100
FSUGC15	Plant Cytology and Genetics	4 (3+1)	25	30	45	100
	Total	**16**				**400**
Students can exit after 3 years with 120 credits awarded UG Degree in Forestry						

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VIIth Semester						
FSUGC16	Plant Biochemistry	4 (3+1)	25	30	45	100
FSUGC17	Introduction to Medicinal & Aromatic Plants	4 (3+1)	25	30	45	100
FSUGC18	Horticulture and Plant Breeding	4 (3+1)	25	30	45	100
FSUGC19	Research Methodology	4 (3+1)	25	30	45	100
	Total	**16**				**400**
VIIIth Semester with research						
FSUGC20	Forest Ecology and Biodiversity Conservation	4 (3+1)	25	30	45	100
FSUGC21	Research Project	12	--	100	200	300
	Total	**16**				**400**
VIIIth Semester without research						
FSUGC20	Forest Ecology and Biodiversity Conservation	4 (3+1)	25	30	45	100
FSUGC21	Plant Biotechnology and Genetic Engineering	4 (3+1)	25	30	45	100
FSUGC22	Restoration Ecology	4 (3+1)	25	30	45	100
FSUGC23	Bioinstrumentation	4 (3+1)	25	30	45	100
	Total	**16**				**400**
Students can exit after 4 years with 160 credits awarded UG Hons Degree in Forestry						

SEC Papers:

1. Economic Botany - Ist Semester
2. Lichenology - IIIrd Semester
3. Bioenergy and Biofuels - IVth Semester

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Detailed Course Structure for 4 Year B.Sc. Forestry (Hons)

FOREST BOTANY

Unit I

Introduction- General classification of plants – Phanerogams, Cryptogams, Angiosperms and Gymnosperms, Dicotyledons and Monocotyledons; General body organization and characters of Algae, Fungi, Bryophytes and Pteridophytes

Unit II

Parts of flowering plants- Root system and Shoot system, typical structure and modifications of root, stem and leaf, Functions of root, stem and leaves, Types of Phyllotaxy and Venation in leaves,

Unit III

Basic Structure of Flower- Essential and Non-essential parts of flower; Morphology of Flower with emphasis on Inflorescence; types of placentation and aestivation in flower.

Unit IV

Basic types of tissues (Structure and Function) - Dermal, Vascular and Ground tissues; Parenchyma, Sclerenchyma, Collenchyma, Chlorenchyma, Aerenchyma, Cambium, Xylem and Phloem; Types of vascular bundles in flowering plants.

Practical: Morphology of root, stem and leaves with special emphasis on underground and aerial modifications in root and stem; simple and compound leaves; types of phyllotaxy and venation (live specimens); typical structure of bisexual flower; types of inflorescence (live specimens); types of tissues with the aid of permanently mounted slides; Tissue organization in Dicot root, stem and leaves; Tissue organization in Monocot root, stem and leaves with the aid of permanent slides or study charts.

Suggested reading:

- Ashok Bendre and Ashok Kumar. (1984). Textbook of Practical Botany. Vol. I and II.Rastogi Publications. Meerut. India. (Also available on Flipkart and Amazon books.Com) Ashok Bendre and P. C. Pande. (1996). Introductory Botany. Rastogi Publications. Meerut. India.
- Ashok Kumar (2001). Botany in Forestry and Environment. Kumar Media (P) Ltd. Gandhinagar, Gujarat.
- Dutta. C. (1998). Botany for Degree Students. (1998). Oxford University Press. India
- Dutta. C. (2000). Class Book of Botany. Oxford University Press. India
- Gurucharan Singh. (2000). Plant Systematics. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Pandey S,N and S.P.Mishra.(2008).Taxonomy of Angiosperms. Ane Books India, New Delhi.

THEORY AND PRACTICES OF SILVICULTURE

Unit I

Definitions: Forests and Forestry- Silviculture objectives and scope of silviculture - relation with other branches of Forestry Silvics. Site factors Climatic, edaphic, physiographic, biotic and interactions.

Unit II

Trees and their distinguishing features, growth and development. Root growth fine root/functional root production - Direct and indirect benefits - biophysical interactions - trees and buffering functions - C sequestration potential of forests.

Unit III

Silvicultural systems - definition, scope and Classification. Systems of concentrated regeneration systems of diffused regeneration - accessory systems - Clear felling systems – Shelter wood system - Selection system and its modifications Coppice systems - Culm selection system in Bamboo, Canopy lifting system in Andaman. Silvicultural systems followed in other countries

Unit IV

Natural regeneration - seed production, seed dispersal, germination and establishment, requirement for natural regeneration, advance growth, coppice, root sucker, regeneration survey, natural regeneration supplemented by artificial regeneration.

Artificial regeneration - object of artificial regeneration - advantages. Factors governing the choice of regeneration techniques. Tree planting - Sowing v/s planting different kinds of pits - tending and cultural operations – weeding - kinds of weeding - release operations - singling, cleaning – liberation cutting.

Practical:

Acquaintance with modern silvicultural tools. Visits to different forest areas/types. Study of forest composition. Visiting plantations raised by forest department, Exercise on nursery practice- seed collection, seed pre- treatment - nursery stock preparation - field preparation - marking, alignment and stacking, pit making - planting, various tending operations - weeding, cleaning, singling, pruning, pollarding, lopping, and thinning - fertilization in trees – plant protection and sanitation measures.

Suggested reading:

- Evans, J. & John W. Turnbull. (2004). Plantation Forestry in the Tropics: The role, silviculture and use of planted forests for industrial, social, environmental and agroforestry purposes. OUP Oxford. 482p.
- Khanna, L.S. (1989). Principles and Practice of Silviculture. Khanna Bandhu, 7 Tilak Marg, Dehra Dun
- Nyland, R. D. (2016). Silviculture: Concepts and Applications, Third Edition. Waveland Press, 680 pages.
- Ram Parkash (1991). Theory and Practice of Silvicultural Systems International Books & Periodicals, Dehra Dun, 298 pages
- Smith, D.M. (1986). Practice of Silviculture, Edn 8. New York, John Wiley

PRINCIPLES OF PLANT PHYSIOLOGY

Unit I

Water relations in plants: role of water in plant metabolism, osmosis, imbibition, diffusion, absorption of water, mechanisms of absorption, ascent of sap. Stomata, structure, distribution, classification, mechanisms of opening and closing of stomata, guttation, Translocation in phloem - Composition of phloem, girdling experiment, Pressure flow model, Phloem loading and unloading.

Unit II

Transpiration-definition, factors affecting transpiration, Plant nutrition- essentiality, mechanism of absorption, role in plant metabolism, Mineral nutrition- Essential elements, macro and micronutrients, Role of essential elements, mineral deficiency symptoms and disorders, Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps.

Unit III

Photosynthesis, importance of photosynthesis, Structure and function of chloroplast, dark and light reactions, CO2 fixation, C3, C4 and CAM, advantages of C4 pathway, Red drop, Emerson effect, Factors affecting the photosynthesis.

Unit IV

Respiration, glycolysis, TCA cycle and Electron transport chain, ATP synthesis and factors affecting the respiration. Photohormones, physiological role in controlling plant process.

Practical: Measurement of water potential by different methods, Osmosis – demonstration, Plasmolysis – demonstration, Root pressure – demonstration, Transpiration rate, Studying the structure of stomata, studying the opening and closing of stomata, Demonstration of importance of light in photosynthesis, Separation of xanthophyll, Chlorophyll in plants, Studying the activity of catalase, Detection of phenols in plants, Studying the plant movements, Root initiation in cuttings.

Suggested reading

- Hopkins, W.G. and Huner, N.P.A. (2008) Introduction to plant physiology. John Wiley and sons. New York
- Larcher, W. (2003). Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functional Groups. Springer Science & Business Media, New York
- Lambers, H., Chapin, F.S. and Pons,T.L. (2008). Plant Physiological Ecology. IInd edition. Springer Scientific & Business Media inc. New York.
- Landsberg , J. and Sands, P. (2011). Physiological Ecology of Forest Production. Principles, Processes and Models. Academic Press Inc., London
- Landsberg, J.J and Gower, S.T (1997). Applications of Physiological Ecology to Forest
- Management. Academic Press Inc., London.
- Nobel, P. S. (2005). Physicochemical and Environmental Plant Physiology. Elsevier Academic Press, Amsterdam
- Pallardy, S.G. (2008) Physiology of woody plants. IIIrd edition. Elsevier Inc. Amsterdam
- Salisbury, F. B. and Ross, C. W. (2004) . Plant Physiology. Thomson Asia Ptd. Ltd. Singapore.
- Taiz, L. and Zeiger, E. (2010) Plant Physiology. 5th edition. Sinauer Associates, Inc., Massachusetts

INTRODUCTION TO FOREST MENSURATION

Unit I

Forest Mensuration- Definition, objectives and scope of forest mensuration. Scales and Units of measurement, error and accuracy.

Unit II

Measurement of individual tree parameters - tree diameter and girth - objectives, standard rules governing measurement at breast height and instruments used. Upper stem diameter measurement- Objective and instruments used. Bark measurements objectives, bark thickness, bark surface area and bark volume. Crown measurement- objectives, crown diameter, crown height, crown surface area and crown volume.

Unit III

Height measurement direct and indirect methods. Height measurement principles- geometric and trigonometric principles, height measuring instruments, error in height measurement and height measurement of learning tree.

Unit IV

Trees stem form- theories, classification of form factors and form quotient. Volume tables- definition, classification and preparation. Tree biomass- objective and biomass estimation methods. Age determination of tree- objective and methods. Tree growth measurement – objectives, increment, determination of increment, stump analysis, stem analysis and increment boring. Measurement of tree crops – objectives, crop diameter, crop height, crop age and crop volume.

Practical: Units of measurement and uses in forestry. Measurements of diameter, girth and upper stem diameter of trees using Calipers, Tape, Ruler, Penta Prism, Criterion Dendrometer etc. Measurement of bark thickness, bark volume, bark area. Measurement of crown diameter, crown area and crown volume. Measurement of tree height using instrumental methods- Abney's level, Ravi Altimeter, Spiegel Relaskop, Clinometer etc. Estimation of form factor. Volume estimation of logs, felled trees and standing trees. Preparation of local volume table. Determination of age of standing trees by increment boring method. Study on stump analysis. Calculation of CAI and MAI.

Suggested readings:

- Chaturvedi, A.N and L.S. Khanna. (2011). Forest Mensuration and Biometry (5th edition).
- Khanna Bandhu. Dehra Dun.364 pp.
- Forest mensuration: A Handbook for Practitioners. (2006). Forestry Commission Publications. 330 pp.
- Husch, B., Beers, T.W. and Kershaw,Jr. J.A. (2002). Forest Mensuration (4th edition). John Wiley & Sons, Nature.456 pp.
- Laar, V. A. and Akca, A. (2007). Forest Mensuration. Managing Forest Ecosystems (Vol.13). Springer.384pp.
- West, P.W. (2009). Tree and Forest Measurement (2nd edition). Springer. 192pp.
- Agarwal, P. (2008). Forest Mensuration- Tree measurement. Bishen Singh Mahendra Pal Singh Publishers & Distributors of Scientific Books, 220pp.
- Panwar, P. and Bhardwaj, S.D. (2005). Handbook of Practical Forestry. Agrobios (India), 191pp.

FOREST PATHOLOGY AND DISEASE MANAGEMENT

Unit I

History and importance of forest pathology in India and the world. Relation of plant pathology with forest pathology and other sciences, classification of tree diseases. Role of microbes and fungi in a natural forest ecosystem. Broad classification of different pathogens causing tree diseases.

Unit II

General characteristics of fungi, bacteria, viruses, yeasts, Growth and reproduction of plant pathogens, infection and factors influencing disease development. Dissemination and survival of plant pathogens. Distribution, economic importance, symptoms, etiology and management of important diseases-bacteria, fungi and virus.

Unit III

Biodegradation of wood in use. Types of wood decay, gross characters of decay, different types of rots in hardwoods, softwoods and their prevention. Graveyard test and decay resistant woods.

Unit IV

Principles of disease management such as exclusion, cultural, chemical, biological and immunization. Nature of disease resistance. Fungicides and their use in nurseries and plantations. Integration of cultural, chemical, biological and host resistance in disease management, Meristem and tissue culture techniques in disease management. Nursery diseases of important forest species.

Practical: Staining techniques, Collection, observation and preservation of diseased specimens and pathogenic structures; Morphological characters of fungi and bacteria; Morphological characters of viruses and phytoplasma; Preparation of culture media, isolation and subculturing of pathogens.

Suggested readings:

- Bakshi, B.K. Forest Pathology. 1976. Principles and Practices in Forestry. Controller of Publications, New Delhi.
- Khanna, L.S. 1984. Forest Protection, Khanna Bandhu, Dehra Dun.
- Beeson, C.F.C. 1941. Forest Insects of India, The Ecology and Control of the Bishen Singh and Mahendrapal Singh, Dehra Dun.
- Ferraz, L.C. and D. Brown. 2002. An Introduction to nematodes - Plant Nematology. Pensoft Publishers. 221 pp.
- Gupta, V.K. and N.K. Sharma. 1988. Tree Protection. Indian Society of Tree Scientists, Solan.
- Herrick, G.W. 1988. Insect Enemies of Trees. Pioneer Publishers, Jaipur.
- Kumar,V. 1995. Nursery and Plantation Practices in Forestry. Scientific Publishers, Jodhpur.
- Speight, M.S. and D. Wainhous 1989. Ecology and Management of Forest Insects. Clarendon Press, Oxford.

TISSUE CULTURE AND TREE BREEDING

Unit I

Introduction- History, scope and basic techniques of in plant tissue culture, sterilization techniques – Physical and Chemical methods. The concept of totipotency

Unit II

Types of media in plant tissue culture (MS, Whites and Gamborg's media), preparation of media and its composition, plant growth regulators in plant tissue culture.

Unit III

Types of culture - callus culture, embryo culture, ovule culture, pollen culture, anther culture, protoplast culture, embryo recue, somatic embryogenesis- Process of somatic embryogenesis, structure, stages of embryo development, factors affecting embryogenesis; production of artificial seeds; Cryopreservation. synthetic seeds,

Unit IV

Micropropagation - Factors affecting morphogenesis and proliferation rate; technical problems in micropropagation. Organogenesis - formation of shoots and roots, production of virus free plants by meristem and shoot-tip culture.

Practical: Sterilization Techniques - Autoclave and Hot Air Oven, Preparation of nutrient media. Establishment of callus culture. Organogenesis in callus cultures, Test tube plants, Micro propagation, synthetic seed

Suggested readings

- Dubey, R. C. (2008). A Textbook of Biotechnology. S. Chand & Co. Ltd., New Delhi.
- Gupta, P. K. (1994). Elements of Biotechnology. Rastogi and Co., Meerut.
- Hammaond, J., McGarvey, P. and Yusibov, V. (2000). Plant Biotechnology. Springer Verlag, Berlin.
- Satyanarayana, V. (2005). Biotechnology. Books and Allied (P) Ltd., Kolkata.
- Singh, B. D. (1998). Biotechnology. Kalyani Publishers, New Delhi.
- Primrose, S. B., Twyman, R. M. and Old, R. W. (2001). Principles of Gene Manipulation. Blackwell Science, London.
- Smith, J.E. (2009). Biotechnology (5th Edition). Cambridge University Press India Pvt. Ltd., New Delhi.
- Bernard B. Glick, Jack J. Pastunak. 2009. Molecular Biotechnology principles and application of Recombinant – DNA
- Prasash M. and Arora. C.K... 1998. Plant tissue culture, Ammol publication Pvt. Ltd.
- Ignacimuthu, S.1997. Biotechnology: An Introduction-2nd Edition, Narosa Publishing House, New Delhi
- Rastogi, S.C. 2007. Biotechnology- Principles and Applications. Narosa Publishing House, New Delhi.
- Bhojwani, S. S. and Razdan, M. K. (1983). Plant Tissue Culture: Theory and Practice. Elsevier Science Publishers, Netherlands.
- Kalyan Kumar, De. (1992). An Introduction to Plant Tissue Culture. New Central Book Agency, Calcutta.
- Ramawat, K. G. (2000). Plant Biotechnology. S. Chand & Co., New Delhi
- Razdan, M. K. (2004). Introduction to Plant Tissue Culture (2 nd ed.). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Reinert, J. and Bajaj, Y. P. S. (1977). Plant Cell Tissue and Organ Culture: A Laboratory Manual, Narosa Publishing House, New Delhi.
- Vasil, I. K. (1986). Cell Culture and somatic Cell Genetics of Plants. 3 Volumes. Academic Press Inc., New York.

WILDLIFE AND CONSERVATION BIOLOGY

Unit I

Definition, History of wildlife management and conservation in India, Values of wildlife - aesthetic, recreational, scientific, educational, commercial, farming, technological and ecological values.

Unit II

Special projects for wildlife conservation: Project Tiger, Operation Rhino, Project Elephant. Protected area (wildlife sanctuaries, national parks, biosphere reserves). In-situ and Ex-situ conservation, Wetland ecosystems and Ramsar sites. Case studies of captive – Red panda and Snow leopard.

Unit III

Habitat requirements of animals. Red Data Book and red listing, IUCN revised red list categories – Extinct, Extinct in the wild, Vulnerable, Near Threatened and Least concerned. Wildlife census: purpose, techniques. Direct and indirect methods of population estimation.

Unit IV

Captive wildlife: Zoos and safari parks. Captive breeding for conservation. Central Zoo Authority of India. Wildlife (Protection) Act, 1972. Special projects for wildlife conservation. Concept of protected areas with special reference to wildlife sanctuaries, national parks, and biosphere reserves.

Practical: Exercise on the census methods - direct method - total count, block count, water hole count, capture - recapture method, point transect, and line transect method – use of software for analysis. Exercise on the census methods - indirect methods, dung count for elephants, pugmark method for larger cats and pellet count for other ungulates. Pitfall trap, mist net, Sherman trap, camera trap, and other traps to study the wildlife. Direct and indirect methods of studying food habits of different wildlife. Studying habitat management and manipulation techniques.

Suggested Reading:

- Davil, J.W. et al. 1981.Infectious diseases of wild mammals. Ed. II. Iowa State University, Press, USA.
- International Zoo Books, Published by New York Zoological Society, New York
- Krebs C & Davis N. 1978. Introduction to behavioural ecology. Oxford University Press
- Lever, C. 1985. Naturalized mammals of the world. John Wiley, London
- Mills, L.S. 2013. Conservation of Wildlife Populations Demography, Genetics and Management (Ed.2). Wiley-Blackwell.
- Rajesh, G. 1995. Fundamentals of Wildlife Management, Justice Home, Allahabad.
- Sawarkar B. Wildlife Management. Wildlife Institute of India. Dehra Dun
- Wildlife Institute of India (2004) Compendium on the notes on the course Captive management of Endangered Species. Wildlife Institute of India. Dehra Dun
- Wodroffe, G. 1981. Wildlife conservation and modern zoo. Saiga Publishing Co., England
- Zoos Print and Zoo Zen, Published by Zoo Outreaches Organization, Coimbatore.

BIOFERTILIZER AND MUSHROOM TECHNOLOGY

Unit I

Biofertilizers- Introduction, scope and application, types of biofertilizers, isolation of nitrogen fixing bacteria.

Unit II

Bacterial Biofertilizers - Mass production of Rhizobium, Azospirillum, Azotobacter, Phosphobacteria and Frankia, fermenter used for biofertilizer.

Unit III

Mushroom: Introduction and Scope of mushroom cultivation, types of edible and poisonous mushrooms in India, Identification of edible and poisonous mushroom food value of mushrooms, Medicinal value of mushrooms, Importance and nutritive value of edible mushrooms.

Unit IV

Isolation and culture of spores, culture media preparation, Production of mother spawn, Multiplication of spawn, harvest and storage methods.

Cultivation of Button mushroom (Agaricus bisporus), Milky mushroom (Calocybe indica), Oyster mushroom (Pleurotus sajor-caju) and Paddy straw mushroom (Volvariella volvacea).

Practical:

Isolation, identification of Rhizobium from root nodules, collection of edible and non-edible mushrooms, Preparation of culture for mushroom production, Spawn production, Cultivation Techniques.

Suggested readings:

- Alice, D., Muthusamy and Yesuraja, M. (1999). Mushroom Culture. Agricultural College, Research Institute Publications, Madurai.
- Dubey, R.C. (2008). A Textbook of Biotechnology. S. Chand & Co. Ltd., New Delhi.
- Marimuthu, T. et al. (1991). Oyster Mushroom, Development of Plant Pathology. Tamil Nadu Agricultural University, Coimbatore.
- Newton, W.E. et al. (1977). Recent Developments in Nitrogen Fixation. Academic Press, New York. 5. Nita Bhal (2000). Handbook on Mushrooms Vols. I & II (2nd ed.). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Pathak, V.N. and Yadav, N. (1988). Mushroom Production and Processing Technology. Agrobios, Jodhpur.
- Schwintzer, C.R. and Tjepkema, J.D. (1990). The Biology of Frankia and Actinorhizal Plants. Academic Press Inc., San Diego, USA.
- Subba Rao, N.S. (1982). Advances in Agricultural Microbiology. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Subba Rao, N.S. (2002). Soil Microbiology (4th ed.) Soil Microorganisms and Plant Growth. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
- Tewari Pankaj Kapoor, S.C. (1988). Mushroom Cultivation. Mittal Publications, New Delhi.
- Tripathi, D.P. (2005). Mushroom Cultivation. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

- Verma, A. (1999). Mycorrhiza. Springer Verlag, Berlin. Kappor, JN. (1999) Mushroom Cultivation. ICAR. New Delhi.

PRINCIPLES OF AGROFORESTRY

Unit I

Overview of the Agriculture scenario – its structure and constraints. Concept of sustainable agriculture and land use management. Paradigm shift in Agriculture development- impacts of green revolution, Agrobiodiversity, significance, threats and conservation strategies.

Unit II

Agroforestry definition and scope – rising demands of fuel wood, fodder and timber. Social, ecological, and economic reasons for agroforestry. History of agroforestry. Components of Agroforestry- provisioning and regulator services of agroforestry.

Unit III

Nutrient cycling, Soil improvement, Increased production and productivity, Microclimate amelioration and carbon sequestration. Tree crop interaction in agroforestry– Definition, kind of interaction – Positive interactions- complementarity - compatibility - mutualism, commensalism - Negative interactions – allelopathy and competition.

Unit IV

Tree Management – structure and growth of trees, crown and root architecture, agroforestry practices to minimize negative interaction – coppicing, thinning, pollarding and pruning – Crop planning and management –selection of suitable crops –management of nutrients, water and weeds.

Practical:

Traditional agroforestry systems in the country and visits to some of the local agroforestry systems. Agroforestry systems in different agroecological zones- their structural and functional features. Visit to on farm agroforestry models. Studies on fodder banks and live fences. Studies on light and below ground interactions in agroforestry systems- Nitrogen fixing trees in agroforestry. Visit to industrial plantations.

Suggested Reading:

- Huxley, P.A. 1983 (ed). Plant Research and Agroforestry, ICRAF, Nairobi, Kenya.
- Huxley, P. 1999. Tropical Agroforestry. Wiley: 384p.
- Kumar, B.M. and Nair, P.K.R (eds). 2011. Carbon Sequestration Potential of Agroforestry Systems: Opportunities and challenges. Advances in Agroforestry 8. Springer Science, The Netherlands: 307p
- Michael, P. 1984. Ecological Methods for Field and Laboratory Investigations. Tata McGraw- Hill Pub. Co. New Delhi.
- Nair, P.K.R, Rao MR, and Buck, L.E (eds), 2004. New Vistas in Agroforestry: A Compendium for the 1st World Congress of Agroforestry, Kluwer, Dordrecht, The Netherlands.
- Nair, P.K.R. 1993. An Introduction to Agroforestry. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Nair, P.K.R. Agroforestry Systems in the Tropics. Springer. 680p.
- Nair, P.K.R., Kumar, B.M. and Vimala D. N. 2009. Agroforestry as a strategy for carbon sequestration. J. Plant Nutr. Soil Sci. 172: 10–23.
- Pathak P.S. and Ram Newaj (eds.) 2003. Agroforestry: Potentials and Opportunities. Agrobios, Jodhpur

CLONAL FORESTRY

Unit I

Clonal Forestry – definition - Basic concepts in clonal forestry – operational use advantages of clonal forestry - constraints –propagation methods - auto and hetero propagation methods – rooting of cutting, grafting, layering, budding-micro –clonal propagation methods – Factors controlling propagation.

Unit II

Plant growth substances - Auxins – cytokinins– gibberellins-ethylene –preparation of powder and liquid formulations – Applications in clonal multiplication.

Unit III

Propagation structures –types of Greenhouse – Polytunnels – Mist Chambers – Shade house– Mini garden–Concepts – Method of establishment – Hedge garden - Management of mini and hedge clonal garden – Clonal Multiplication Area (CMA) – Clonal Testing Area (CTA)

Unit IV

Designs of clonal evaluation – Amplified clonal test – Clonal plantation establishment - management strategies –Problem and constraints in clonal forestry.

Practical: Clonal nursery– Study of propagation methods– Propagation Chambers – Mist chamber – Green house. Establishment of low cost polytunnels–Cost of establishment and management- Establishment of CMA and CTA – Clonal evaluation –Visit to clonal forests

Suggested readings:

- Ahuja, M.R. and Libby, W.J. (Eds.) (1993). Clonal Forestry I Genetics and Biotechnology. Springer - Verlag., Berlin
- Ahuja, M.R. and Libby, W.J. (Eds.) (1993) Clonal Forestry II: Conservation and Application. Springer - Verlag., Berlin
- Hartman, H.T., D.E. Kester, F.T. Davies and R.L. Geneve. (2010). Hartmann & Kester's Plant Propagation: Principles and Practices. Prentice - Hall of India Pvt. Ltd., New Delhi.
- Parthiban K.T., Paramathma, M., Neelakantan, K.S. (2004). Clonal Forestry. TNAU Publications, Coimbatore.
- Surendran, C., K.T. Parthiban, K. Vanagamudi and S. Balaji. (2000). Vegetative propagation of trees - Principles and Practices. .FC&RI Publication, Mettupalayam.
- Zobel, B. and J. Talbert. (1991). Applied Forest Tree Improvement. John Wiley and Sons, New York.

DENDROLOGY

Unit I

Introduction – Importance and scope of dendrology, Principles and systems of plant classification. Detailed study of Bentham and Hooker natural system, its advantages and disadvantages. Plant Nomenclature – objectives, principles and International Code of Botanical Nomenclature.

Unit II

Role of vegetative morphology in identification of woody forest flora. Peculiarities of bole, general form of woody trunk and deviations like buttresses, flutes, etc. Morphology and description of barks of common trees. Characteristics of blaze, bark colour, exudations etc.

Unit III

Morphology of leaf, different types of leaves, colour of young and old leaves in some species as (regular) features of identification. Reproductive morphology of plants with reference to description and identification of reproductive parts.

Unit IV

Detailed study of the families- Annonaceae, Malvaceae, Rutaceae, Meliaceae, Fabaceae, Combretaceae, Myrtaceae, Rubiaceae, Sapotaceae, Apocyanaceae, Lamiaceae, Lauraceae, Euphorbiaceae, and Poaceae.

Practical: Morphological description of plant parts and method of collection of plants. Techniques of preparing herbarium specimens. General study of herbarium. Dissection of flowers-making sketches-construction of floral diagrams of the following families: Annonaceae, Malvaceae, Rutaceae, Meliaceae, Fabaceae, Combretaceae, Myrtaceae, Rubiaceae, Sapotaceae, Apocyanaceae, Lamiaceae, Lauraceae, Euphorbiaceae, and Poaceae.

Suggested Reading

- Ashok Kumar (2001). Botany in Forestry and Environment. Kumar Media (P) Ltd. Gandhinagar, Gujarat. • Bor N. L. (1990). Manual of Indian Forest Botany. Periodical Expert Book Agency. New Delhi.
- Brandis. D. Revised by R. D. Jakarti (2010). Indian Trees. Dehradun.
- Charles McCann. (1966). 100 Beautiful Trees of India. D. B. Taraporevala Sons & C. Pvt. Ltd. Mumbai. (Available online PDF)
- Father H. Santapau. (1966). Common Trees. (Available online PDF) Gurucharan Singh. (2000). Plant Systematics. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Hardin, W., Harrar, E.S., and White, F.M. (1995) Textbook ofDendrology (8th Edition). McGraw-Hill Companies, London
- Jain S. K. and R. R. Rao. (1977). Handbook of Field and Herbarium Methods. Today and Tomorrow's Printers and Publishers. New Delhi.
- Lawrence, G.H.M.(1967). Taxonomy of Vascular Plants. Oxford&IBH, New Delhi.
- Mishra. S.R. (2010). Textbook of Dendrology. Discovery Publishing House Pvt. Ltd. New Delhi.
- Naqshi. R. (1993). An Introduction to Botanical Nomenclature. Scientific Publishers. Jodhpur.
- Pandey S. N. and S. P. Mishra. (2008). Taxonomy of Angiosperms. Ane Books India, New Delhi.
- Parker. R. N. (1933). Forty Common Indian Trees and How to know them. (Available online PDF)
- Randhawa. M. S. (1957). Flowering Trees in India. Sree Saraswati Press Ltd. Kolkatta.
- Sahni. K. C. (2000). The Book of Indian Trees. Bombay Natural History Society. Mumbai.
- Tewari D. N. (1992). Tropical Forestry in India. International Book Distributors, Dehradun

FOREST BIOTECHNOLOGY

Unit I

Concepts and history of plant biotechnology: scope and importance in tree improvement: Totipotency and morphogenesis, nutritional requirements of in-vitro cultures; techniques of in-vitro cultures,

Unit II

Micro propagation, anther culture, pollen culture, ovule culture, embryo culture, test tube fertilization, endosperm culture, factors affecting above in-vitro culture, Applications and Achievements, somaclonal variation-types, reasons:

Unit III

Somatic embryogenesis and synthetic seed production technology, Protoplast isolation, culture, manipulation and fusion; Products of somatic hybrids and cybrids.

Unit IV

Applications in tree improvement. Genetic engineering, Restriction enzymes, Vectors for gene transfer – gene cloning, Direct and indirect method of gene transfer.

Unit V

Transgenic plants, their applications, achievements and biosafety regulations, blotting techniques – DNA finger printing and bar coding, DNA based markers – RFLP, AFLP and RAPD.

Practical: Requirements for plant tissue culture laboratory. Techniques in plant tissue culture; media components and preparations; sterilization techniques and inoculation of various explants; callus induction and plant regeneration, synthetic seed production. Isolation of DNA DNA quantification. Demonstration of gene transfer techniques, agarose gel electrophoresis technique, SDS-PAGE

Suggested Reading:

- Bajaj, Y.P.S.(Ed) (1988). Biotechnology in Agriculture and Forestry 2. Crops 1. Springer- Verlag, Berlin.
- Dhawan, V (2012) Applications of Biotechnology in Forestry and Horticulture. Springer US
- Guptha, P.K. (2000). Elements of Biotechnology. Rastogi publications, Meerut.
- Neumann, K.H., Kumar,A., and Sopory, S.K.(2008)Recent Advances in Plant Biotechnology and Its Applications. I. K. International Pvt Ltd
- Punia, M.S. (1998). Plant Biotechnology and Molecular Biology. A laboratory manual. Scientific Publishers, Jodhpur
- Thieman, W.J. and Palladino, M.A. (2009). Introduction to Biotechnology, Second Edition. Pearson Benjamin Cummings, San Fransis.

WOOD SCIENCE

Unit I

Introduction to wood anatomy. Kinds of woody plants-Gymnosperms versus angiosperms. The plant body; a tree and its various parts.

Unit II

Meristems; promeristem, primary meristem, secondary meristem. Simple tissues; parenchyma, collenchyma, sclerenchyma and the vascular tissues. Secondary growth in woody plants.

Unit III

Mechanism of wood formation with special reference to typical dicot stem. Ray initials and fusiform initials; anticlinal and periclinal division. Physiological significance of wood formation. The macroscopic features of wood, sapwood, heartwood, pith, early wood, late wood, growth rings, wood rays, etc. Sapwood versus heart wood.

Unit IV

Microscopic features of wood. Prosenchymatous elements, tracheids, vessels, fibers. Parenchymatous elements, parenchyma and rays, resin canals, gum canals, latex canals, Three dimensional features of wood; transverse, tangential and radial surfaces. Elements of wood cell walls. The structure and arrangement of simple pit, bordered pits. Comparative anatomy of gymnosperms and angiosperms. Anatomical features of common Indian timbers; classification into porous and nonporous woods, ring porous and diffuse porous woods.

Practical: Study of primary growth in stems of typical dicots and monocots. Study of wood formation in typical dicot stem. Study of vascular bundles in monocots. Timber identification and its importance. Procedures for field identification of timbers. Study of anatomical features of wood, pores or vessels, different types. Study of soft tissue in timbers and their different types of distributions. Study of wood rays, and their different types. Study of the non-porous woods, their physical and anatomical description. Biochemical and thermochemical conversion of wood

Suggested Reading

- Anoop, E. V.,Antony, F.,Bhat, K. V. Lisha, D. A. and Babu, L. C. 2005. Anatomical key for the identification of important timbers of Kerala. Kerala Agricultural University, Thrissur and Kerala State Council for Science, Technology and Environment, Thiruvananthapuram, Kerala, India. 126p.
- Hoadley, B. 2000.Identifyingwood-Accurate results with simple tools. Taunton Press, New town, USA. 223p.
- Panshin, A. J. and De Zeeuw, C. 1980. Textbook of wood technology, 4th Ed. McGraw-Hill. New York, USA: 722p.
- Rao, R. K. and Juneja, K. B. S. 1992. Field identification of fifty important timbers of India. Indian Council of Forestry Research and Education, New Forest, Dehra Dun. 123p.

SOIL BIOLOGY AND FERTILITY

Unit I

Introduction - forest soils vs. cultivated soils, special features of forest soils, forest soil formation and vegetation development. Pedogenic processes – Podzolization and Laterization.

Unit II

Properties of soils under different forest ecosystems. Forest floor – stratification – types of humus. Essential nutrient elements-occurrence, availability and their functions. Diagnosis of nutrient deficiencies-visual symptoms, soil fertility evaluation methods.

Unit III

Site productivity and nutrient cycling in forest soils. N, P and K, macro and micronutrient fertilizers and their uses. Forest soil-biology-distribution of various microorganisms in soil ecosystem and their interaction effects. Role of microorganisms in soil fertility.

Unit IV

Bio-fertilizers – their importance. Nitrogen fixation-Rhizobium, asymbiotic and associative N2 fixation. Nitrification and denitrification in forest ecosystems. Microbial transformation of phosphorous, sulphur, and micronutrients.

Practical: Study of forest soil profile; Estimation of pH and EC –Organic carbon – available N, P, K, Ca, Mg, S. Basic sterilization techniques; culturing and maintenance of microorganism occurring in soil; Staining methods; Study of decomposition of forest litter by CO_2 – evolution method; Estimation of nitrification rate in soil; Isolation of legume bacteria, Preparation and inoculation techniques for mycorrhizae and biofertilizers.

Suggested readings:

- Brady, NC. The Nature and Properties of Soils. Mac Millan Pub. Comp. New York.
- Burges, A. and Raw, F. 1967. Soil Biology. Acad. Press, New York
- Mengel, K. and Kirkby, A. 1978. Principles of Plant Nutrition. International Potash Institute, Switzerland • Pritchett and Fisher RF 1987. Properties and Management of Forest Soils. John Wiley, New York.
- Tisdale, L. S. Nelson, L.W.and Beaton, J. D. 1985. Soil Fertilityand Fertilisers. Macmillan Publishing Company, New York
- Young, A. 1989. Agroforestry for Soil Conservation. CAB International, U.K

PLANT CYTOLOGY AND GENETICS

Unit I

History of genetics. Pre -Mendelian concepts, Mendels principles of inheritance – segregation – independent assortment. Cell reproduction – Mitosis – meiosis and its significance.

Unit II

Gametogenesis and syngamy in plants. Chromosome theory of inheritance, Evidence for chromosome as bearers of genes. Modification to Mendelian inheritance – multiple alleles – codominance –gene interaction –epistasis –pleotrophy – polygenic inheritance – penetrance and expressivity cytoplasmic inheritance.

Unit III

Linkage and crossing over – cytological consequence of crossing over. Detection of linkage and linkage maps. Sex determination – theories. Sex linked and other sex - related inheritance. DNA as the genetic material.

Unit IV

Structure of DNA and its replication. Chromosomes – its structure and function. Chromosomal aberrations - numerical and structural. RNA its structure function and types. Molecular structure of genes. Protein synthesis and gene expression

Practical: Study of fixatives and stains; Preparation of slides showing various stages of mitosis; Preparation of slides showing various stages of meiosis; Testing the viability and germination of pollen grains; Solving the problems on monohybrid and dihybrid crosses; Estimation of linkages/chromosome mapping.

Suggested reading:

- Fletcher, H. and Hickey, I. (2012). Genetics (4th ed.). Garland Science, Taylor & Francis, U. K. 371p
- Garner, E. J., Simmons, M. J. and Sunstad, P. D. (2008). Principles of Genetics (8th edn.) Wiley India (P .) Ltd., Daryaganj, New Delhi.

- Gupta, P. K. (1999). Cytogenetics Rastogi Publishers, Meerut
- Strickberger, M. W. (1996). Genetics (3rd edn.). Mac Millan Publishing Co., New Delhi
- Tamarin, R. (2002). Principles of Genetics (7th Ed). Tata McGraw - Hill Education.
- Timothy L. White, T.L., Adams, W.T. and Neale, D.B. (2007). Forest Genetics, CABI Publishing, Oxfordshire, UK FB

PLANT BIOCHEMISTRY

Unit I

Carbohydrates-occurrence and classification-structures of glucose, fructose, ribose, maltose, lactose, starch and cellulose, physical and chemical properties of carbohydrates. Introduction to nucleic acids: DNA and RNA

Unit II

Lipids classification-important fatty acids and triglycerides, essential fatty acids -rancidity of oils acids value, saponification value & iodine value -phospholipids-types and importance-plant pigments-structure and function of chlorophyll and carotenoids.

Unit III

Protein - classification - functional and solubility - amino acids-classification and structure essential amino acids - properties of amino acids-colour reactions, amphoteric nature and isomerism-structure of proteins – primary, secondary, tertiary and quarternary properties and reactions of proteins.

Unit IV

Enzymes-classification and mechanism of action-factors affecting enzyme action, carbohydrate metabolism-glycolysis and TCA cycle. Enzyme immobilization

Practical: Preparation of standard solutions and reagents – estimation of carbohydrates (anthrone method) –proteins by Lowry method – lipid (Soxhlet method and Bligh & Dyer method) determination of acid value, saponification value, iodine number of vegetable oils.

Suggested Reading

- Conn, E.E. and Stumpf, P.K. (1989). Outlines of Biochemistry, WileyEastern Ltd., New Delhi
- Mazur, Aand Harrows, B. (1971). Textbook of Biochemistry. W.B.Sanders Publications, New Delhi.
- William, H.E. and Daphne, C.E. (2005). Biochemistry and Molecular Biology, Oxford University Press.
- Robert, C.B. (1983). Modern concepts in Biochemistry. Allyn and Bacon Inc. London.

INTRODUCTION TO MEDICINAL AND AROMATIC PLANTS

Unit I

Role of medicinal and aromatic plants in national economy, history, scope, opportunities and constraints in the cultivation, utilisation and processing of medicinal and aromatic plants in India.

Unit II

Physiological disorders, role of growth regulators and macro and micronutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management, training and pruning.

Unit III

Plant protection, harvesting, processing and economics of under mentioned important medicinal and aromatic plants. Medicinal Plants: Black pepper, cardamom, clove, ginger, turmeric, Rauvolfia, Dioscorea, Cinchona and other species relevant to local conditions.

Unit IV

Aromatic Plants: Citronella grass, khus grass, sweet flag (bach), lavender, geranium, patchouli, bursera, Mentha, muskdana (musk mallow), Ocimum and other species relevant to the local conditions. Endangered medicinal and aromatic plants of India, Study of chemical composition of important medicinal and aromatic plants.

Practical: Morphological description and identification of various medicinal plants. Collection of medicinal plants and plant parts from natural habitats. Survey and study of nursery techniques including training and pruning of medicinal plants. Harvesting, drying, grading, storage and processing techniques. Preparation of medicinal plant extracts and their phytochemical profiling, Visit to a nearby medicinal and aromatic plantation area /nursery /ayurvedic pharmacies /pharmaceutical industries.

Suggested readings:

- Chadha, K.L. 2001. Handbook of Horticulture. ICAR Publication, Krishi Anusandhan Bhavan, Pusa, New Delhi.
- Farooqi, A.A. and B.S. Sreeramu. 2001. Cultivation of Medicinal and Aromatic Crops. Universities Press (India) Ltd. 3-5-819, Hyderguda, Hyderabad – 29.
- Handa, S.S. and M.K. Kaul. 1987. Cultivation and Utilization of Medicinal Plants. RRL, Jammu.
- Shanmugavelu, K.G., N. Kumar and K.V. Peter. 2002. Production Technology of Spices and Plantation Crops. Agrobios Publications, Bikenar, Rajasthan.

HORTICULTURE AND PLANT BREEDING

Unit I

Introduction – Importance – Scope of horticulture – Divisions of horticulture – Pomology, Olericulture, Floriculture and Arboriculture, Classification of horticultural crops, Garden implements & tools. Types of gardens – Formal, Informal and Kitchen Garden, Establishment and maintenance of Lawn.

Unit II

Methods of Plant Propagation – Cutting, Layering, Grafting and Budding. Stock – Scion relationship in grafting. Nursery preparation and maintenance, Role of growth hormones in horticulture – root induction, flowering, fruit setting, fruit development, seedless fruits and control of fruit drop.

Unit III

Floriculture – commercial flowers - cultivation of Rose, Jasmine, Chrysanthemum and Crossandra, cut flowers – Indoor plants – Bonsai, cultivation of fruit trees – Mango, Banana and Sapota, Manures – organic manure and chemical fertilizers (N,P,K).

Unit IV

Introduction & scope, Selection – pure line, mass, and clonal. Hybridization – selfing and crossing techniques, Heterosis, Hybrid vigour – causes and achievements, Micropropagation, somatic embrogenesis, anther and embryo culture, green house, lathhouse, hotbeds and cold

beds. Types of plant reproduction – vegetative, sexual and apomixis, Breeding for disease resistance

Practical: Emasculation, study of floral biology of wheat, gram and mustard, hybridization techniques in wheat, gram and ground nut, propagation by layering, budding, grafting, preparation of nursery beds for root stock and seedling.

Suggested readings:

- Kumar, N. (1987). Introduction to Horticulture, Rajalakshmi Publishers, Nagercoil.
- Manibushan Rao, K. (1991). Textbook of Horticulture. Macmillan Publishing Co., NewYork.
- Rao, K. M. (2000). Textbook of Horticulture. Macmillan India Ltd., New Delhi.
- V.L. Sheela. (2011). Horticulture. MJP publishers, India.
- Chopra, V. L. (1989). Plant Breeding. Oxford & IBH Publishing Co. Pvt. Ltd., NewDelhi.
- Sundararaj, D. D. and Thulasidas, G. and Durairaj, M. S. (1997). Introduction to Cytogenetics and Plant Breeding. Popular Book Depot, Chennai.
- Vijendra Das, L. D. (1998). Plant Breeding. New Age International Publishers, New Delhi.
- Arora, J. S. (1992). Introductory Ornamental Horticulture. Kalyani Publishers, NewDelhi.
- Edmond, J. B. et al. (1977). Fundamentals of Horticulture. Tata McGraw Hill Publishers Co. Ltd., New Delhi.
- George Acquaah. (2002). Horticulture Principles and Practices. 2nd ed. Pearson Education, Delhi.
- Sundararajan J.S. et al. A guide to Horticulture. Thiruvenkadam Printers, Coimbatore.

FOREST ECOLOGY AND BIODIVERSITY CONSERVATION

Unit I

Historical development of ecology as a science. Levels of biological organization. Major forest Ecosystem. Forest environment- major abiotic and biotic components and their interaction, Nutrient cycling, trophic levels, food webs, ecological pyramids and energy flow.

Unit II

Population ecology - definition, population dynamics and carrying capacity, preparation of life table and its importance in forest management. Community ecology- species interactions, ecological succession, terminology, basic concepts, theories of succession- climax vegetation types, forest management and succession.

Unit III

Autecology of important tree species. Perturbation ecology- Biodiversity and conservation – definition, levels of study, distribution of diversity in life forms, hotspots of biodiversity, measurement of diversity and diversity indices.

Unit IV

Principles of conservation biology, Ex situ and In situ methods of conservation, Genetic and evolutionary principles in conservation. Biosphere concept. Conservation – efforts in India and worldwide.

Practical: Study of ecological modifications in plants; Effects of fire on forest ecosystem; Study of population dynamics using model systems; Preparation of life tables; Study of spatial dispersion among plants; Study of Forest composition; Niche analysis; Computation of diversity indices; Measurement of diversity of plants and insects in a nearby forest; Study of succession in field and water bodies; Visit to different ecosystems.

Suggested reading:

- Odum EP 1983. Basic Ecology. Saunders College Publishing, Philadelphia etc. 613p.
- Misra KC 1974. Manual of Plant Ecology. Oxford &IBH Pub Co. New Delhi etc. 491p.
- Michael P. 1984. Ecological Methods for Field and Laboratory Investigations. Tata McGrawHill Pub.Co. New Delhi, 404p.
- Montagnini, F and Jordan, C.F. 2005. Tropical Forest Ecology: The Basis for Conservation and Management. Springer. 295p.
- Frankel, O.H., Brown, A.H.D., Burdon, J.J. 1995. The Conservation of Plant Biodiversity. Cambridge University Press. Cambridge. 299p.
- Saggwal, S.S. 1995. Forest Ecology of India. Pioneer Publishers, India. 368p.
- PD Sharma, 2013. Ecology and Environment. (11th Edition), Rastogi Publications, Meerut.
- Kimmins JP. 1976. Forest Ecology. MacMillan.
- Nautiyal S & Koul, AK. 1999. Forest Biodiversity and its Conservation Practices in India. Oriental Enterprise.

PLANT BIOTECHNOLOGY AND GENETIC ENGINEERING

UNIT I

Recombinant DNA Technology: Major events, screening and selection of recombinants (blue - white selection, colony hybridization), blotting techniques (southern, northern and western), marker genes and reporter genes, DNA finger printing, PCR.

UNIT II

Tools of genetic engineering, enzymes (exonuclease, endonuclease and restriction endonuclease), ligase, alkaline phosphatase, reverse transcriptase, DNA Polymerase, use of likers and adaptors.

UNIT III

Cloning vectors- plasmids (pBR322, pUC), cosmid, YAC and BAC phage, Ti and Ri plasmid, gemini virus, tobamo virus.

Unit IV

Methods of gene transfer: vector less gene transfer method -chemical method (PEG), physical method-electroporation, gene gun, microinjection, Liposome mediated gene transfer, vector mediated gene transformation –agrobacterium mediated gene transformation.

Practical: Isolation of plasmid from E.coli, isolation of plant DNA from leaf, restriction digestion, agarose gel electrophoresis for DNA separation.

Suggested readings:

- Dubey, R. C. (2008). A Textbook of Biotechnology. S. Chand & Co. Ltd., New Delhi.
- Gupta, P. K. (1994). Elements of Biotechnology. Rastogi and Co., Meerut.
- Satyanarayana, V. (2005). Biotechnology. Books and Allied (P) Ltd., Kolkata.
- Singh, B. D. (1998). Biotechnology. Kalyani Publishers, New Delhi.

- Primrose, S. B., Twyman, R. M. and Old, R. W. (2001). Principles of Gene Manipulation. Blackwell Science, London.
- Smith, J.E. (2009). Biotechnology (5th Edition). Cambridge University Press India Pvt. Ltd., New Delhi.
- Bernard B. Glick, Jack J. Pastunak. 2009. Molecular Biotechnology principles and application of Recombinant – DNA
- Ramawat, K. G. (2000). Plant Biotechnology. S. Chand & Co., New Delhi.

RESTORATION ECOLOGY

Unit I

Degraded lands: concept, classification, status, extent and causes of degradation/ wastelands. Different types of degraded lands – physical, chemical and biological land degradation., concept of eco-restoration

Unit II

Soil erosion- types, causes and mechanism, measures to control erosion, ravine and sand dune formation and their control measures.

Unit III

Salt affected soils- classes of salt affected soils, causes, extent and their effects on plant growth and afforestation / reclamation practices. Acid soils definition, characteristics, causes and afforestation.

Unit IV

Afforestation and reclamation, Desertification- definition, impact and causes, prevention and counter measures (shelter belts and wind breaks). Soil pollution-types, effects and control measures through forestry techniques. National and state level programmes on degraded lands/wasteland development. Role of Government agencies and NGO's in degraded lands/wasteland development programme.

Practical: Selection criteria tree species suitable for different degraded lands. Identification and study of various degraded lands. Visit to nearby degraded lands and afforestation programme. Preparation restoration plan for a piece of degraded land.

Suggested Reading:

- Anilkumar and Pandey, RN 1989. Wastelands Management in India. Ashish Publishing House, New Delhi
- Buol, S.W., Kole, F.D. and McGracken, R.J. 1975. Soil Genesis and Classification. Oxford and IBH Publ. New Delhi.
- Butler, B.E. 1980. Soil Classification for Soil Survey. Clerneder Press-Oxford Publ. Co., London.
- Gregersen, H. Draper, S. and Elz. D.(eds.) 1989. People and Trees-The Role of Social Forestry in Sustainable Development EDI Seminar Series, The World Bank, Washington, D.C.273p
- Hegde NG 1987. Handbook of Wasteland Development. BAIF, Pune 102p.
- Hegde NG and Abhyankar 1986 (eds). The Greening of Wastelands. BAIF, Pune 204p
- IARI 1960. Soil Survey Manuel, IARI. New Delhi.
- ICAR 1977. Desertification and its Control. ICAR, New Delhi 358p.
- National Commission on Agriculture 1976. Report of the National Commission on Agriculture, Part ix,

- Prasad, V. N. 1985. Principles and Practices of Social-Cum-Community Forestry. International Book Distributors, Dehradun, 108p
- Shah, S. A. 1988. Forestry for People. ICAR, New Delhi, 147p
- Sharma, S. C.,Chaturvedi R. Band Mishra O. P 1990. Utilization of Wastelands for Sustainable Development In India. Concept Publishing Co. New Delhi-59, 488p

BIOINSTRUMENTATION

Unit I

Cellular Analysis and Separation Process: Principle and Applications of Optical microscope, phase contrast, Electron Microscope, Principles of Sedimentation and types of centrifugations.

Unit II

Chromatography and Spectroscopy: Principles and applications of Chromatography- Paper chromatography- Thin layer chromatography, Ion exchange chromatography- Affinity chromatography- Adsorption chromatography, GC-MS and HPLC. Principles and applications of colorimeter and spectrophotometer-UV- Vis spectrometer.

Unit III

Electrophoresis and Blotting Techniques Principles of Electrophoresis- Agarose and polyacrylamide gel electrophoresis, Southern Blotting, Northern Blotting-Western blotting. Labelling of DNA probes for blotting analysis.

Unit IV

Molecular Techniques: Principles of Polymerase Chain Reaction- Types of PCR: Multiplex PCR, Nested PCR, Hot start PCR, Touchdown PCR, Assembly PCR, Colony PCR, Overlap PCR, and Quantitative Real Time PCR.

Practical: Plant tissue section for microscopical study, paper and thin layer chromatography, UV Sepctrophometery, electorophorosis, handling of DNA thermocycler

Suggested readings:

- Wilson, K., and Walker, J., (1999). Practical Biochemistry: Principles and Techniques, Cambridge University Press.
- Geddes L.A., and Balsar L.E (2003). Principles of Applied Biomedical Instrumentation- John Wiley and Sons.
- Srivastava, M.L., (2011). Bioanalytical Techniques (2011), Narosha Publishers, New Delhi. Skoog, D. A., Holler, F.J., and Nieman, S.R., (1998). Principles of Instrumentation, Cengage Learning Press.
- Freifelder, D., (1983). Applications to Biochemistry and Molecular Biology,W.H.Freeman Publisher.
- Chatwal, G.R and Anand, S.K. (2009). Instrumental methods of Chemical Analysis, Himalaya Publishing House, New Delhi.
- Plummer, D.T. (2008). An Introduction to Practical Biochemistry, Tata McGraw- Hill Publication, New Delhi.
- Boyer, R.F. (2011). Biochemistry Laboratory: Modern theory and techniques, Prentice Hall Publishers. 8. Wilson, K. and Walker, J. (2000). Principles and Techniques of Practical Biochemistry, Cambridge University Press Publishers.
- Okotore, R.O. (2008). Basic Separation Techniques in Biochemistry. New Age International Pvt Ltd Publishers.

- Palanivel, P. (2000). Laboratory Manual for Analytical Biochemistry & Separation Techniques, School of Biotechnology, Madurai Kamaraj University, Madurai.
- Sawhney, S.K. and Singh, R. (2005) Introductory practical Biochemistry, Narosa Publishing House, New Delhi.

Skill Enhancement Courses

ECONOMIC BOTANY

Unit I

Introduction to Economic Botany & Food Plants-Definition and Scope of Economic Botany, Origin of Cultivated Plants-Food Plants

A. Cereals: Rice, Wheat, Maize – origin, cultivation, uses
B. Legumes: Chickpea, Pigeon pea – origin, nutritional value, uses
C. Millets: Sorghum, Pearl millet – significance in food security

Spices and Condiments-

A. Black pepper, Cardamom, Turmeric – plant parts used, cultivation, uses.

Unit II

Industrial and Commercial Plants, Oil yielding plants- Groundnut, Mustard, Coconut – economic importance and processing, Fiber yielding plants: Cotton, Jute – cultivation, processing, uses, Beverages: Tea, Coffee – processing and economic value, Rubber: Natural rubber – extraction and applications, Timber and Wood Products: Teak, Sal – properties and uses.

Unit III

Medicinal, Physcoactive & Ethnobotanical Aspects - Medicinal Plants: Neem, Tulsi, Ashwagandh, Haldi etc – traditional and modern applications, Psychoactive Plants: Opium, Cannabis, Tobacco – legal and ethical aspects, Ethnobotany: Concept of Ethnobotany, Role in tribal medicine and traditional knowledge systems, Conservation and sustainable use of economically important plants.

LICHENOLOGY

Unit I:

Lichen: Definition, phycobiont and mycobiont**,** General features of Lichens, distribution, Classification (Miller).

Unit II

Types – crustose, foliose and fruticose, thallus organization, vegetative & sexual reproduction, lichens as indicators of pollution & economic importance.

Unit III

Mycorrhiza: Definition, distribution, types of mycorrhiza (Ecto and Endo), isolation of spores from soil, culture methods, role of mycorrhiza in agriculture and forestry. Benefits of mycorrhizal biofertilizer.

Suggested readings:

- Hale, M.E.Jr. (1983). Biology of Lichens. Edward Arnold, Maryland.
- Schwintzer, C.R. and Tjepkema, J.D. (1990). The Biology of Frankia and Actinorhizal Plants. Academic Press Inc., San Diego, USA.
- Verma, A. (1999). Mycorrhiza. Springer Verlag, Berlin

BIOENERGY AND BIOFUELS

Unit I

Fundamentals of Bioenergy- Concept of energy, Introduction to renewable and non-renewable energy sources-Concept of biomass, Classification and categorization of biomass, biomass characterization- Introduction to biomass conversion (biochemical and thermochemical) - Introduction to Energy Forestry, Energy crops-Jatropha, Sugarcane, Algae, invasive species – potential and cultivation

Unit II

Biofuel Types and Production, Bioethanol-Production from sugar and starch-based biomass, Biodiesel-Production from vegetable oils (transesterification process), Biogas-Anaerobic digestion – substrates, process, advantages, 3rd generation biofuels: Algae-based fuels-Biofuel production from wastes, Concepts of bioreactors and fermentation technology

Unit III:

Applications, Challenges, and Future Prospects, Environmental concerns, Carbon neutrality, Energy balance and life-cycle analysis of biofuels, Socio-economic aspects and rural development, Challenges: Land use, Food vs. Fuel debate, scalability, Biofuel policy (India)

Suggested readings:

- Dahiya, A, 2014. Biomass to biofuels, 1st edition
- Kellomaki, S, Kilpelainen, A and Alam, A, 2013. Forest Bioenergy production: Management, carbon sequestration and Adaptation
- Thiffault, Smith, Junginger and Berndes, 2016. Mobilisation of Forest Bioenergy in the boreal and temperate biomes.
- M. Mathiyazhagan, 2011, Assessment of fuel efficiency of biodiesel from non-edible oils and waste oil, Ph.D. thesis, Bharathidasan University, Tiruchirappalli, Tamilnadu. Satyanarayana, V. (2005). Biotechnology. Books and Allied (P) Ltd., Kolkata.
- Manickam Mathiyazhagan, 2021, Biodiesel Technology, LAP Lambert Academic Publishing, available on Amazon.
- M.Mathiyazhagan G.Bupesh and Meenakshi Sundaram, 2022, Biodiesel and its Environmental impact and sustainability, Environmental Degradation; Challenges and strategies for Mitigation, Springer,