

Department of Botany and Microbiology

M.Sc. Botany

Two year PG Program

As per NEP 2020

Course Contents & Syllabus

(w.e.f. Academic Session 2026-27)



Hemvati Nandan Bahuguna Garhwal University

(A Central University)

Srinagar Garhwal-246174 (Uttarakhand)

M.Sc. Botany Two-Year Program as Per NEP 2020
P.G. Second Year

	III Semester		IV Semester	
Course Category	Course Title	Credits (T+P)	Course Title	Credits (T+P)
Discipline Specific Core (DSC)	DSC-7: Innovations in Plant Biotechnology	3+2	DSC-11: Modern Approaches in Plant Taxonomy	3+2
	DSC-8: Sustainable Ecosystem Management and Restoration	3+2	DSC-12: In Vitro Culture of Plants	3+2
	DSC-9: Plant Disease and Protection Strategies	3+2	DSC-13: Advanced Algal Biotechnology	3+2
	DSC-10: Economic Botany and Plant-Based Bioeconomy	3+2	DSC-14: Climate Change and Plant Responses	3+2
Optional Component (Research / Skill Oriented) in lieu of DSC			Option-I: Minor Dissertation / Project Work (in lieu of any one DSC)	5
			Option-II: Major Dissertation / Project Work (in lieu of any two DSCs)	10
Discipline Specific Elective (DSE) DSE-3 and 4. (Anyone from DSE-3 in Sem I & DSE 04 in Semester II)	DSE-03A: Resources Utilization, IPR and Ethnobotany. DSE-03B: Palynology and Pollination Biology	3+1	DSE-04A: Forest Ecosystems DSE-04B: Botanical Perspectives in Organic Farming	3+1
	or		or	
Multidisciplinary Elective (MDE) MDE- 3 and 4. (Anyone from MDE-3 in Sem I & MDE 4 in Semester II)	MDE-3A: Nanobiotechnology in Life Sciences MDE-3B: Environmental Pollution and Sustainable Development	3+1	MDE-4A: Biomonitoring in Plant Science MDE-4B: Introduction to Research Methodology and Scientific Writing	3+1
SEC (Non-CGPA Course)	Academic Library Systems and Services	1	Community Outreach Activities	1
	or Entrepreneurship & Startup Awareness	1		
Total Credits		24		24
NHEQF Level- 6.5	Student after successfully completing 1-Year PG Programme i.e., securing minimum 48 credits will be awarded “Postgraduate Degree” of one year, in related field/discipline/subject.			

M.Sc. Botany III Semester

DSC-07 Innovations in Plant Biotechnology

[3 Credits]

Unit-1

Introduction – History, scope and applications of plant biotechnology. Aseptic culture techniques and culture of plant tissues via callus and suspension type cultures. types of chemically defined media and use of growth regulators for root and shoot induction.

Unit-2

Plant cell protoplast isolation, protoplast culture and somatic hybridization, cytoplasmic hybridization, Protoplast transformation and use of plant protoplast for the localization of recombinant proteins. Large scale production of plants through micropropagation.

Unit-3

DNA delivery methods in plants. Production of transgenic plants via Agrobacterium mediated gene transfer. Mechanism of crown gall and hairy root production. Amplification of target genes via PCR, isolation of target genes via cDNA cloning and expression construct production for transgenic expression.

Unit-4

Production of transgenic plants for drought tolerance, salt stress tolerance, flooding stress tolerance, resistance against various pathogens and for the production of recombinant proteins. Metabolic engineering - Molecular farming of proteins, carbohydrates and fatty acids (Omega 3 & 6).

Recommended Books:

1. Adrian Slater, Nigel W Scott, And Mark R Fowler, 2011, Plant Biotechnology. The genetic manipulation of plants, second edition, oxford university press. ISBN: 9780199560875.
2. S. Ignasimuthu, 1997, Plant Biotechnology, oxford university press and IBH publishing.
3. Chirikjian Jack G, Kisailus Edward, King Baldwin, Krasner Robert, Mortensen, Harley, Graf, Karen, 1995, Biotechnology: Theory and Techniques, Jones and Bartlett publishers, Vol-1 and Vol-2.
4. Oksman-Caldentey, Kirsi-Marja, Barz, Wolfgang H, 2002, Plant Biotechnology and Transgenic plants, Marcel Dekker publishers, New York.
5. Plant Biotechnology, 2022, BD Singh, MedTech Science Press, ISBN: 9789393168092.

DSCL-7: Innovations in Plant Biotechnology Lab

[2 Credits]

1. Demonstration of transgenic plant production via Agrobacterium mediated gene transfer.
2. Demonstration of total DNA isolation from plants tissues by CTAB method.
3. Demonstration of plasmid DNA isolation from bacterial cells via alkaline lysis method

Unit I

Concept of Conservation; origin and evolution of organism, genetic plasticity a factor in evolution; the invasion of unoccupied ecological niches; Global and regional patterns of biodiversity, Distribution, Gradients, Magnitude of biodiversity, keystone species, effects of species deletion and addition on maintenance of biodiversity; Major terrestrial biomes; biogeographical zones of India.

Unit II

Uses of biodiversity: food, fodder, timber, fiber, medicine, etc. Biodiversity-based products and industries, wild relatives of cultivated plants.

Unit III

Survey and monitoring of plant bio-resources: sampling population for conservation; Collection and analysis of inventory data, criteria on choice of species for conservation; Sustainable use and People participation; biodiversity registers and their maintenance.

Unit IV

Protected Area Network with special reference to Uttarakhand and India; International efforts for conserving biodiversity, Wetland conservation, Rangeland management, Acts and conventions: (Wildlife (Protection) act, 1972; Forest (Conservation) Act, 1980; Environment (Protection) Act, 1986; Biodiversity Act, 2002).

Recommended Books:

1. Cain, M.L., Bowman, W.D. & Hacker, S.D. 2008. Ecology. Sinauer Associates, Inc.
2. Groombridge, B. and Jenkins, M.D. 2000. Global Biodiversity. Earth's living resources in the 21st century, UK. World Conservation Monitoring Center. Pp 246.
3. Hunter, Jr, M.L. & Gibbs, J.P. 2006. Fundamentals of Conservation Biology. Wiley Blackwell.
4. Primack, R.B. 2008. A Primer of Conservation Biology. Sinauer Associates, Inc.
5. Singh, J.S., Singh, S.P. & Gupta, S.R. 2007. Ecology, Environment, and Resource conservation. Anamaya Publishers, New Delhi.

DSCL-08 Sustainable Ecosystem Management and Restoration Lab**[2 Credits]**

1. Study of different diversity indices for community analysis using standard sampling techniques.
2. Study of moisture, water holding capacity, bulk density and porosity of different soil types.
3. Study of some key stone species of Uttarakhand.
4. Visit to any conservation site or community-based biodiversity management committee and report preparation.

Unit 1: Fundamentals of Plant Pathology

Plant disease – definition, causes and classification of plant diseases on the basis of pathogen dissemination, symptoms and causal factors, Types of plant pathogens (fungi, bacteria, viruses), role of inoculum, pathogen's enzymes and toxins in plant diseases.

Unit 2: Plant diseases

Various stages of plant diseases development (Disease cycle), Impacts of plant diseases in crop yield and nations economy. General symptoms of plant diseases. Methods and procedures and diagnosis of plant diseases. Koch's postulates and pathogenesis mechanisms. Role of biotic (insects, worms and nematodes) and abiotic factors in plant disease production.

Unit 3: Host-Pathogen Interaction

Plant immune responses (morphological, anatomical and molecular adaptations against invading pathogens), role of secondary metabolites (alkaloids, Phenolics and Phytoalexins) in plant defense mechanisms, plant cell mediated defense mechanisms and plant defense pathways.

Unit 4: Plant Pathogenesis

Resistance genes (R genes) of plants, Specialized pathogen structures in pathogenesis and dissemination. Virulent proteins from pathogens, gene silencing suppressor proteins and symptom determinant proteins from plant DNA viruses. Invading plant synthetic pathways by plant viruses.

Recommended Books:

1. P. D. Sharma, 2004, Plant Pathology, Rastogi publications.
2. H.C. Dube, 2010, Modern Plant Pathology, Agrobios publications.
3. R. S. Mehrotra, 1980, Plant Pathology, TATA McGraw Hill publications.
4. S.K. Tripathi, M.S. Bhale, V.K. Yadav, Ashish Srivastava, 2023, Fundamentals of plant pathology, Scientific publishers.
5. B.P.Panday, 1982, Plant Pathology, Pathogen and plant diseases, S. Chand Publications.

DSCL-09 Plant Disease and Protection Strategies Lab**[2 Credits]**

1. Identification of diseased plant specimens (Mosaic symptoms, Leaf curling, leaf spots, rust symptoms)
2. Macro and microscopic examination of root nodule bacteria and its isolation.
3. Field visits to observe seasonal / annual disease outbreaks.

Unit I: Fundamentals and Food Plants

Concept, scope and importance of Economic Botany; plant resources and their economic significance; origin and domestication of crop plants, vegetables, major food and beverage plants, cultivation, processing and value addition.

Unit II: Industrial and Commercial Plants

Oil-yielding plants (mustard, groundnut, sesame, coconut); fibre-yielding plants (cotton, jute, flax, hemp and bamboo); sugar and starch-yielding plants; rubber, gums, resins and timber-yielding plants; their products, processing, industrial applications and economic importance.

Unit III: Medicinal, Aromatic and Spice Plants

Medicinal plants and their bioactive compounds; aromatic and essential-oil plants. Cultivation, processing and utilization of plants such as neem, tulsi, ashwagandha, turmeric, ginger, black pepper and nutraceuticals.

Unit IV: Plant-Based Bioeconomy and Sustainable Utilization

Concept and principles of plant-based bioeconomy and circular bioeconomy; plant biomass and its valorization; natural dyes, bioplastics, biofuels, bio-based products and green technologies; sustainable harvesting and conservation; waste-to-value approaches; entrepreneurship, intellectual property and commercialization of plant-based products.

Recommended Books:

1. Kochhar, S. L. (2016). *Economic Botany: A Comprehensive Study* (5th ed.). Cambridge University Press.
2. Simpson, B. B., & Ogorzaly, M. C. (1995). *Economic Botany: Plants in Our World* (2nd ed.). McGraw-Hill.
3. Society for Economic Botany. *Economic Botany* — a major interdisciplinary journal covering plant uses, plant products, and relationships between plants and people.

DSCL-10 DSC-10:Economic Botany and Plant-Based Bioeconomy Lab**[2 Credits]**

1. Identification and study of economically important plants and their useful parts.
2. Herbarium preparation and documentation of selected economic plants.
3. Extraction of essential oil by hydrodistillation.
4. Preparation of a natural dye from plant material.

DSE-03A: Resource Utilization, IPR & Ethnobotany

1. Plant resources: Concept, status, utilization and concerns.
2. World Centers of Primary Diversity of domesticated plants
3. Origin, evolution, botany, cultivation, cytotaxonomy and uses of (i) Cereals and millets (wheat, paddy, maize), (ii) Legumes (soybean, black gram and cowpeas), (iii) Sugar cane and starches (sugarcane, beetroot, potato, sweet potato, cassava), (iv) Forage and fodder crops.
4. Fiber crops, medicinal and aromatic.
5. Important firewood and timber yielding plants and non- wood forest products (NWFPs) such as bamboos, gums, tannins, dyes, resins, beverages.
6. Intellectual Property Rights, Concept, History, Protection of IPR; Patent- requirements, procedures and limitations; International convention on Biological Diversity.
7. Ethnobotany: Concept, linkage with other sciences, tools of ethnobotanical studies, world and Indian perspective with special reference to the Himalayas.
8. Green revolution: Benefits and adverse consequences.
9. Plants used as ornamentals and avenue trees.
10. Principles of conservation: Extinction; Status of plants based on International Union for Conservation of Nature (IUCN).
11. Strategies for conservation: In situ conservation; Protected areas in India- sanctuaries, national parks and biosphere reserves.

Recommended Books:

1. Baenzinger, S.P., Kleese, R.A. and Barns, R.F. 1993. Intellectual Property Rights, Protection of plant materials; executive summary and work group reports. CSSA Publication No. 21. Crop Science Soc. of America, Wisconsin, Madison.
2. Bellamy, R. 1993. Ethnobotany in Tropical forests: expedition in field techniques, Royal Geographic Society of London.
3. Berlin, B. 1992. Ethnobiological Classification: Principles and categorization of plants and animals in traditional societies. Princeton Univ. Press. Princeton.
4. Chandel, K.P.S., Shukla, G. and Sharma, N.1996. Biodiversity in Medicinal and Aromatic Plants in India: Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.

DSE Elective Lab-3: (DSE-03A)**[Credit -1]**

1. Food crops: wheat, rice, maize, chickpea, potato, tapioca, sweet potato, sugarcane; morphology, anatomy and micro chemical tests for stored food materials.
2. Forage/fodder plants: Study of ten important fodder crops of the locality.
3. Plant fibers: Textiles fibers (cotton, jute, sun hemp, cannabis, Grewia, etc.), Cordage fibers (coir), Stuffing fibers (silk cotton). Morphology, anatomy, microscopic study of whole fibers using appropriate, staining procedures.

1. General Introduction, microsporogenesis, microspore tetrads and polarity of spores and pollen grains.
2. Pollen wall development and pollen chemistry, Chemical nature of sporopollenin, development of pollen wall, Ubisch body, pollen wall proteins, origin and formation exineless pollen grains; pollen expressed and pollen specific genes.
3. **Spore-pollen morphology:** Symmetry, shape, size, aperture patterns, NPC System for numerical expression of apertural details, exine stratification, surface structures and sculptures of sporoderm; LO-analysis and edge-analysis.
4. **Paynotaxonomy:** Systematic palynology, identification key and evolutionary trends among pollen grains based on palynotaxonomical works.
5. Aeropalynology with reference to allergy: Aeroallergens, introductory idea of Immune System with special reference to IgE. Study of airspora, identification of allergic taxa by in- vivo and in-vitro tests with spore-pollen extracts, chemical nature of exine-borne allergens, allergic taxa of North-West Himalaya.
6. **Melissopalynology:** Indian species of honey bees, importance of pollen grains as constituent of bee-bread, pollen-collecting mechanism of honey bees, analysis of pollen load and honey sample in understanding bee forage, objectives of melissopalynological studies, important bee plants of North- West Himalaya.
7. **Forensic palynology:** Definition and significance, a few well-known case studies.
8. **Pollination Biology:** Pollen dispersal units; pollination types, contrivances for cross- and self-pollination; pollen vectors, pollination modes and flora organization, Pollen viability and storage, evolutionary trends in pollination modes.

Recommended Books:

1. Crane, Eva; Walker, Penelope and Day Rosemany. 1984. Directory of Important World Honey Sources: International Bee Research Association, London.
2. Erdtman, G. 1952. Pollen Morphology and Plant Taxonomy, Angiosperms; Almquist and Wiksell, Stockholm.
3. Knut Segril, Johnson Iverson. 1975. Text book of pollen analysis 3rd edition. Blackwell Publ.
4. Nair, P.K.K. 1966. Essentials of Palynology; Asia Publication House Lucknow.
5. Woodhouse, R.P. 1935. Pollen Grains: Hafner Publication Co.

DSE Elective Lab-3: (DSE-03B)**[1 Credit]**

1. Pollen morphological studies of some pterodophytes, gymnosperms, and angiosperms representing different morphological types using acetolysis / alkali maceration method.
2. Extraction of pollen grains from honey sample and study of the frequency of different morpho-types.
3. Study of in vivo and in vitro germination of pollen grains.

Unit I: Introduction to Nanobiotechnology: Concepts of nanotechnology and nanobiotechnology, nanoparticles and nanomaterials, their major types and properties. Applications of nanotechnology in biology and medicine.

Unit II: Synthesis and Characterization: Methods of nanoparticle synthesis, including physical, chemical and biological methods. Green synthesis using plants and microorganisms. Nanoparticle characterization techniques such as UV-Visible spectroscopy, FTIR, SEM and TEM.

Unit III: Applications in Life Sciences: Applications of nanoparticles in medicine, drug and gene delivery, antimicrobial activity and nano-biosensors. Nanotechnology in agriculture, food science, cancer diagnosis and treatment.

Unit IV: Nanotoxicology and Future Applications: Effects of nanoparticles on living organisms, basic concepts of nanotoxicology, environmental effects, biosafety and ethical considerations. Advantages, limitations and future applications of nanobiotechnology in life sciences.

Recommended Books:

1. Bhushan, B. (Ed.). (2017). *Springer handbook of nanotechnology* (4th ed.). Springer.
2. Khan, I., Saeed, K., & Khan, I. (2019). Nanoparticles: Properties, applications and toxicities. *Arabian Journal of Chemistry*, 12(7), 908–931.
3. Mourdikoudis, S., Pallares, R. M., & Thanh, N. T. K. (2018). Characterization techniques for nanoparticles: Comparison and complementarity upon studying nanoparticle properties. *Nanoscale*, 10, 12871–12934.
4. Nel, A., Xia, T., Mädler, L., & Li, N. (2006). Toxic potential of materials at the nanolevel. *Science*, 311(5761), 622–627.

MDE-3A: Nanobiotechnology in Life Sciences Lab**[1 Credit]**

1. The basic preparation of nanoparticles by green synthesis using plant extracts.
2. Observation of nanoparticle formation, UV-Visible spectroscopic analysis
3. Study of antimicrobial activity, nanoparticle size and stability

Unit I: Environmental Pollution - Basic Concepts

Concept of environmental pollution, its major types and sources. air, water, soil and noise pollution, their major pollutants, sources, effects on plants, methods of pollution monitoring and control.

Unit II: Air and Water Pollution

Major sources and effects of air and water pollution. Greenhouse gases, acid rain, smog, industrial emissions, sewage, eutrophication, water-borne pollutants.

Unit III: Soil Pollution and Waste Management

Soil pollution, including pesticides, fertilizers, heavy metals, plastics and industrial wastes. Solid-waste management, wastewater management, recycling, composting, bioremediation and the role of microorganisms and plants in environmental cleanup.

Unit IV: Sustainable Development and Environmental Conservation

Principles of sustainable development, sustainable use of natural resources, biodiversity conservation, renewable energy, climate change, Sustainable Development Goals (SDGs).

Recommended Books:

1. Alloway, B. J. (Ed.). (2013). Heavy metals in soils: Trace metals and metalloids in soils and their bioavailability (3rd ed.). Springer.
2. Gadd, G. M. (2004). Microbial influence on metal mobility and application for bioremediation. *Geoderma*, 122(2–4), 109–119.
3. IPCC. (2022). Climate change 2022: Mitigation of climate change. Cambridge University Press.
4. Manahan, S. E. (2017). Environmental chemistry (10th ed.). CRC Press.
5. United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. United Nations.

1. Determination of pH and turbidity of different water samples.
2. Estimation of dissolved oxygen (DO) and biological oxygen demand (BOD) in water samples.
3. Determination of soil pH and moisture content in different soil samples.

M.Sc. Botany IV Semester

DSC-11 Modern Approaches in Plant Taxonomy

[3 Credits]

Unit I

Modern classification

Evolution of modern plant taxonomy; Integrative taxonomy-concept and significance; Species concepts (Biological Species Concept, Morphological Species Concept, Phylogenetic Species Concept, Evolutionary Species Concept), Angiosperm Phylogeny Group classification.

Unit II

Molecular Approaches in Plant Taxonomy

Plant genomes, Molecular markers, DNA extraction methods, DNA sequencing, Genome skimming, Phylogenetic trees, Dichotomy, Polytomy, Sister group, Outgroup, Phylogenetic analysis, Species delimitation using molecular evidence.

Unit III

Electron Microscopy, Phytochemistry, Nutraceuticals and Bioinformatics

Electron Microscopy: SEM, TEM, Its applications in plant taxonomy, Phytochemistry: Introduction of Primary metabolites, Secondary metabolites, Micromolecular data: Alkaloids, Flavonoids, Terpenoids, Polyacetylenes, Betalains, Glucosinolates, Glycosides, Iridoid compounds; Macromolecular data: Semantides, Proteins, and Nucleic Acids; Genomics, Transcriptomics, Proteomics. Nutraceuticals: Study of the following herbs as health food: Alfalfa, Chicory, Ginger, Fenugreek, Garlic, Amla, Ginseng, Ashwagandha, Spirulina. Bioinformatics: GenBank, IPNI, POWO, GBIF, Tropicos, World Flora Online, Index Herbariorum, BHL, JSTOR Global Plants.

Unit IV

Digital Taxonomy, Conservation and Future Perspectives

Digital herbaria, Virtual herbarium, Herbarium digitization, Taxonomic databases, GIS and Remote Sensing in plant taxonomy, Species Distribution Modeling (MaxEnt concept), Citizen Science, IUCN Red List assessment, Taxonomy in biodiversity conservation, Taxonomy and climate change, Taxonomy for ecological restoration, New species description, Typification, Electronic publication.

SUGGESTED READINGS:

1. Subrahmanyam, N. S. (1995). *Modern plant taxonomy*. Vikas Publishing House.
2. Singh, G. (2019). *Plant systematics: Theory and practice* (4th ed.). CRC Press.
3. Sharma, O. P. (2017). *Plant taxonomy*. McGraw Hill Education.
4. Sivarajan, V. V. (1991). *Introduction to the principles of plant taxonomy* (2nd ed.). Cambridge University Press.

DSCL-11 Plant Disease and Protection Strategies Lab

[2 Credits]

1. Sequence retrieval from GenBank, BLAST analysis, Handling of QGIS software
2. Image-based plant identification, Construction of simple phylogenetic trees
3. Herbarium digitization and taxonomic database search
4. Preparation of taxonomic descriptions
5. Citation of type specimens and Photo-plate preparation

DSC-12 In Vitro Culture of Plants

[3 Credits]

Unit I: Advanced Principles of Plant Tissue Culture, History and scope of plant tissue culture, Cellular totipotency and developmental plasticity, Tissue culture laboratory design and aseptic techniques, Surface sterilization of explants, Culture media: Murashige and Skoog (MS), Gamborg's B5. Plant growth regulators: Auxins, Cytokinins, Gibberellins, Absciscic acid.

Unit II: Specialized In Vitro Culture Techniques, Callus culture, Cell suspension culture, Single-cell culture, Protoplast isolation, culture, and fusion. Somatic hybridization, Embryo culture and embryo rescue, Anther and pollen culture (haploid production), Ovary and ovule culture, Endosperm culture.

Unit III: Micropropagation and Organogenesis, Stages of micropropagation, shoot tip and meristem culture, Axillary bud proliferation, Organogenesis (direct and indirect), Somatic embryogenesis, Synthetic seed technology, In vitro rooting and acclimatization, Hardening of regenerated plants.

Unit IV: Germplasm Conservation and Genetic Improvement, In vitro conservation, Slow-growth storage, Cryopreservation, Synthetic germplasm banks, Somaclonal variation, In vitro mutagenesis.

Recommended Books:

1. Bhojwani, S. S., & Razdan, M. K. (1996). *Plant tissue culture: Theory and practice* (Revised ed.). Elsevier.
2. George, E. F., Hall, M. A., & De Klerk, G.-J. (Eds.). (2008). *Plant propagation by tissue culture* (3rd ed.). Springer.
3. Pierik, R. L. M. (1997). *In vitro culture of higher plants*. Springer.
4. Trigiano, R. N., & Gray, D. J. (Eds.). (2016). *Plant tissue culture, development, and biotechnology*. CRC Press.
5. Gamborg, O. L., & Phillips, G. C. (Eds.). (1995). *Plant cell, tissue and organ culture: Fundamental methods*. Springer.

DSCL-12 In Vitro Culture of Plants Lab

[2 Credits]

1. Histological zonation studies on Shoot and Root Apical Meristems of developing tissues. Effect of plant hormones on growth patterns.
2. Demonstration of Plant tissue culture techniques such as callus production, multiple shoot induction and somatic embryogenesis.
3. Demonstration of initiation and maintenance of plant suspension cell culture.

DSC-13: Advanced Algal Biotechnology

[3 Credits]

Unit I: Introduction to Algal Biotechnology

Importance of algae in the modern world, Diversity of microalgae and macroalgae, Economic importance of algae, Algal resources and germplasm conservation, Commercially important algal species

Unit II: Modern Algal Cultivation Technologies

Open pond cultivation systems, Closed photobioreactors, Fermentation and heterotrophic cultivation, Optimization of growth conditions (light, nutrients, CO₂, temperature), Scale-up techniques for industrial cultivation

Unit III: Algal Harvesting and Biomass Processing

Harvesting techniques; Centrifugation, Flocculation, Filtration, Membrane technology, Biomass drying and preservation, Cell disruption methods, Extraction of lipids, proteins, carbohydrates, and pigments

Unit IV: Algal Biotechnology Applications

Biofuel production (biodiesel, bioethanol, biogas, hydrogen), Nutraceuticals and functional foods, Pharmaceutical compounds, Pigments (phycocyanin, astaxanthin, β -carotene), Cosmetics and personal care products, Animal and aquaculture feed.

Suggested Readings:

1. Bux, F., & Chisti, Y. (Eds.). (2016). *Algae Biotechnology: Products and Processes*. Springer, Cham.
2. Barsanti, L., & Gualtieri, P. (2023). *Algae: Anatomy, Biochemistry, and Biotechnology* (3rd ed.). CRC Press.
3. Verma, P. (Ed.). (2022). *Micro-algae: Next-generation Feedstock for Biorefineries—Contemporary Technologies and Future Outlook*. Springer, Singapore.
4. Tripathi, B. N., & Kumar, D. (Eds.). (2017). *Prospects and Challenges in Algal Biotechnology*. Springer, Singapore.
5. Mandotra, S. K., Upadhyay, A. K., & Ahluwalia, A. S. (Eds.). (2021). *Algae: Multifarious Applications for a Sustainable World*. Springer, Singapore.

DSCL-13: Advanced Algal Biotechnology Lab

[2 Credits]

1. Isolation and purification of algal cultures, Cultivation using different culture media
2. Microscopic identification of microalgae & Biomass estimation
3. Pigment extraction and analysis and Lipid estimation
4. Operation of a laboratory-scale photobioreactor
5. Wastewater treatment using algae

Unit I: Climate Change and Plant Environment: Global climate changes and its major causes, greenhouse gases, the enhanced greenhouse effect, rising atmospheric CO₂, global warming, and changes in temperature, precipitation and radiation.

Unit II: Physiological Responses of Plants: Plant responses to temperature extremes, elevated CO₂, drought, salinity, heat and cold stress. Changes in photosynthesis, respiration, plant water relations, stomatal regulation and water-use efficiency, antioxidant defence mechanisms.

Unit III: Growth, Development and Reproduction: Effects of climate change on seed germination, seedling growth, plant phenology, flowering, fruiting and senescence. Effects on pollen viability, pollination and seed production, impacts of climate change on crop productivity.

Unit IV: Plant Adaptation, Mitigation and Future Perspectives: Plant adaptation and acclimation to changing climatic conditions, climate change impacts on plant biodiversity, migration and distribution, role of plants and forests in carbon sequestration, climate-smart agriculture, sustainable plant production, conservation strategies and future challenges.

Suggested Readings:

1. Ainsworth, E. A., & Long, S. P. (2005). What have we learned from 15 years of free-air CO₂ enrichment (FACE)? A meta-analytic review of the responses of photosynthesis, canopy properties and plant production to rising CO₂. *New Phytologist*, 165(2), 351–372
2. Atkinson, N. J., & Urwin, P. E. (2012). The interaction of plant biotic and abiotic stresses: From genes to the field. *Journal of Experimental Botany*, 63(10), 3523–3543.
3. Parmesan, C., & Hanley, M. E. (2015). Plants and climate change: Complexities and surprises. *Annals of Botany*, 116(6), 849–864.
4. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant physiology and development* (6th ed.). Sinauer Associates.
5. Lambers, H., Chapin, F. S., III, & Pons, T. L. (2008). *Plant physiological ecology* (2nd ed.). Springer.

DSCL-14: Climate Change and Plant Responses Lab

[2 Credits]

1. Effect of Temperature on Seed Germination: Study the effect of different temperature conditions on seed germination percentage, germination rate and seedling growth.
2. Effect of Water Stress on Plants: Study the effect of different levels of water availability on seed germination, root growth and shoot growth.
3. Effect of Salinity Stress: Determine the effect of different concentrations of NaCl on seed germination and early seedling growth.
4. Study of Stomatal Responses: Observe and compare stomatal density and stomatal behaviour under different environmental conditions using leaf epidermal peels.

Optional Component (Research / Skill Oriented) in lieu of DSC

Option–I: Minor Dissertation / Project Work (*in lieu of any one DSC*) **[5 Credits]**

Option–II: Major Dissertation / Project Work (in lieu of any two DSCs) **[10 Credits]**

DSE 04A: Forest Ecosystems

1. Forests, forestry and man: Definition, forests in geological ages, forests in prehistoric era, shifting cultivation, forests in historical time, scientific forestry, forest policy, natural forest policy, private forest policy, planned forest development, forestry education in India.
2. Essential elements of forest ecology: Extent and boundaries, physical features, geology, river system, soil, land-use pattern, role in country's economy, forests and wild lands.
3. Forests and trees: Locality factors of the forests, forest influences, forest composition, stand structure, dynamics and growth, classification, forest types and their distribution, species diversity
4. Wild Life: Species and distribution, Sanctuaries, Biosphere reserves, wild life and recreation.
5. Forest conservancy and Potential Productivity: Soil, Water relation and nutrition, soil erosion and conservation, potential productivity of forests, site quality evaluation.
6. **Forest Conservation and Management:**
 - i. Impact of deforestation on soil and water, Role of fire: type, extent and cause of fire, fuel load, fire and different forest types of Himalaya.
 - ii. Forest resource management and forest resource information system.
 - iii. Forest cover in India-State of Art, Ground inventory. Application of Remote Sensing and
 - iv. Geographic Information System (GIS) in Land cover mapping. Vegetation and forest type maps.
7. Environmental Impact Assessment: Maintenance and conservational policies such as Joint Forest Management (JFM) and Agroforestry in the region.

SUGGESTED READINGS:

1. Bir, S.S. and Chatha, G.S. 1988. Forest Vegetation Characteristics of Indian Hills. Today and Tomorrow's Printers & Publ., New Delhi.
2. Mishra, R. and Gopal, B. Recent Advances in Tropical Ecology: Part I & II. International Society for Tropical ecology, Varanasi.
3. Negi, S.S. 1983. Forest Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.
4. Puri, G.S., Gupta, R.K., Meher-Homji, V.M. and Puri, S. 1989. Forest Ecology: PlantForm,

DSE Elective Lab-IV: (DSE-04A)**[Credit: 1]**

1. To undertake studies on stand analysis, dominance, diversity and similarity coefficient.
2. To make studies on gradient analysis.
3. To identify different forest types of the locale.
4. Prepare profile diagram of forest stands using Single Plot Method.

Unit I: Organic Farm

Organic farming - concept, characteristics, significance, organic ecosystem, scope of organic farming in India - Principles and types of organic farming. Choice of crops & varieties in organic farming - Initiative by Govt/NGOs/Other organizations for promotion of organic farming. Operational structure of NPOP (National Programme for Organic Production). Organic production methods for cereals, vegetables and fruit crops.

Unit II: Soil Science

Organic farming for sustainable agriculture; Manures - compost, methods of composting - Green manuring, vermicompost and biofertilizer Harmful effect of non-judicious chemical fertilization - Organic farming practices for improving soil health Quality parameters of organic manures and specifications - Soil fertility in organic farming systems Manure preparation methodology - Soil improvement.

Unit III: Fundamental of Organic Farm Management

Land management in organic farming - Water management in organic farming. Organic insect disease management - Organic pest disease management. Preventive and cultural methods for insects and pest control - Identification of different fungal and bacterial biocontrol agents. Indigenous technical knowledge for insects-pest, disease - Weed and nutrient management in organic farming.

Unit IV: Post-Harvest Management

Processing, labeling of organic produce - Storage and transport of organic produce.

Unit V: Organic Quality Control Standards

Certification- types, process & procedure and agencies. Quality aspect and grading - Packaging and handling. Economic considerations and viability of organic products - Export of organic product and marketing.

SUGGESTED READINGS:

1. Palaniappan, S. P., & Annadurai, K. (2018). *Organic Farming: Theory and Practice*. Scientific Publishers, Jodhpur.
2. Reddy, S. R. (2017). *Principles of Organic Farming*. Kalyani Publishers, New Delhi.
3. Panda, S. C. (2011). *Organic Farming for Sustainable Agriculture*. Kalyani Publishers, New Delhi.
4. Lampkin, N. (1990). *Organic Farming*. Farming Press Books, Ipswich, UK.

DSE Elective Lab-IV: (DSE-04B)**[1 Credit]**

1. Organic Mulching Experiment on soil moisture.
2. Study the effect of biofertilizers inoculation on plant growth.
3. Seed Germination Test Using Organic Treatments
4. Preparation of Vermicompost using earthworms.

Unit I: Introduction to Biomonitoring

Definition and concept of biomonitoring, Environmental pollution and its sources, Bioindicators, biomonitors and biosensors, Importance and applications of biomonitoring, Types of biomonitoring: Active and Passive

Unit II: Plant-Based Biomonitoring

Plants as environmental indicators, Characteristics of an ideal biomonitoring, Role of lichens, mosses, algae and higher plants, Plant responses to environmental stress.

Unit III: Biomonitoring Techniques

Sampling methods and site selection, Collection and preservation of plant samples, Laboratory analysis of pollutants, Use of chlorophyll estimation, leaf injury index and biochemical markers, Data interpretation and environmental assessment.

Unit IV: Practical Applications and Case Studies

Biomonitoring of urban and industrial pollution, Monitoring agricultural pollution, Environmental Impact Assessment (EIA), National and international biomonitoring programmes, Case studies on lichen, moss and tree biomonitoring.

MDE-4A: Biomonitoring in Plant Science Lab**[1 Credit]**

1. Collection and identification of biomonitor plants from polluted and non-polluted sites.
2. Observation of leaf injury symptoms.
3. Heavy metal analysis (demonstration).
4. Preparation of field reports and data interpretation.

1. **Introduction of Scientific writing**
2. **Basics of Research**
Concept of Research, Characteristics of Research and, Types of Research. Meaning and purpose of scientific writing, Characteristics of scientific writing, Types of scientific documents Structure of a scientific paper, Principles of academic writing.
3. **Research Problem**
Identification and formulation of a research problem, Literature Review, Variables, Hypotheses, Operational Definition.
4. **Research Design**
Design in Qualitative Study, Design in Quantitative Study, Ideal Research Design
5. **Sampling**
Basics of Sampling, Sampling Techniques, Probability sampling, Cluster sampling.
6. **Data Collection Methods and Analysis**
Different Collection Methods, Ethics in Data Collection and Data Analysis, Observation Interviews Questionnaires Surveys.
7. **Research Proposal**
Study Plan, Introduction, Problem Statement, Literature Review, Research Objectives & Research Questions, Framework, Hypotheses.
8. **Final report Submission**
Structure of a research report, Title page, Abstract, Introduction, Literature review, Methodology, Results, Discussion, Conclusion and recommendations, References, Appendices, Report formatting and presentation.

Recommended Books:

1. Pandey, P., Pandey, M.M. 2015. Research Methodology: Tools and Techniques: Tools and Techniques (ISBN 978-606-93502-7-0)
2. Jansirani, S., Taibangnganbi, N., Rajesh Kanna, R. 2023. Research Methodology (ISBN 978 -93 - 5747 -070-4).
3. Kothari, C.R. 2004. Research Methodology (Methods and Techniques), New Age International (P) Ltd., Publishers (ISBN (13): 978-81-224-2488-1)

MDE-4B: Introduction to Research Methodology and Scientific Writing Lab**[1 Credit]**

1. Abstract Writing: Write a concise summary of a research study.
2. Literature Review: Summarize and critically evaluate published studies.
3. Research Paper Structure, Figure and Table Legends and write informative captions.
4. Referencing Practice: Use citation styles correctly.