

Department of Botany and Microbiology

M.Sc. Botany

Two-year PG Program

As per NEP 2020

Course Contents & Syllabus

(w.e.f. Academic Session 2025-27 only)



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) - Third semester

Semester	Course Category	Course title	Credits		Total Credit
			T	P	
III	DS Core	Core-1: DSC-07 Innovations in Plant Biotechnology	5		
		Core-2: DSC-08 Sustainable Ecosystem Management and Restoration	5		
		Core-3: DSC-09 Plant Disease and Protection Strategies	5		
		DSC Core Lab-III: BCL-03 Based on Core X,XI, & XII		3	
	DS Elective (Any 1 out of Minimum 2 electives)	DS Elective-III: BE-03 (Anyone from BE-03) BE-03A: Resources Utilization, IPR and Ethnobotany BE-03B: Palynology and Pollination Biology	4		
		Elective Lab-III: BEL-03 (BE-03A/BE-03B)		2	
Total			19	05	24

P.G. (Second Year) - Fourth semester

Semester	Course Category	Course title	Credits		Total Credit
			T	P	
IV	DSCore	Core 1-: DSC-10 Modern Approaches In Plant Taxonomy	5		
		Core 2: DSC-11 In Vitro Culture of Plants	5		
		Core 3: DSC-12 Advanced Algal Biotechnology	5		
		Core Lab-IV: BCL-04 Based on Core X,XI, & XII		3	
	DSElective (Any 1 out of Minimum 2 electives)	Elective-IV: BE-04 (Anyone from BE-04) BE-04A: Forest Ecosystems BE-04B: Botanical Perspectives in Organic Farming	4		
		Elective Lab-IV: BEL-04 (BE-04A/BE-04B)		2	
Total			19	05	24

M.Sc. Botany IIInd Semester

DSCore-VII: DSC-07 Innovations in Plant Biotechnology

[5 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. Use of geminiviral genomes as vectors for gene delivery.

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).

Unit-5

Over-expression of target genes, Use of CaMV 35S promoter and other strong promoters for transgene expression. Applications of plant gene silencing and anti-sense RNAi technology in crop improvement, Chloroplast transformation and its advantages.

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.

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).

Unit V

Ecosystem restoration, Strategies and plans for restoration, Passive restoration (natural recovery) and active restoration.

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.

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.

Unit 5:

Symptomatology of some important diseases: White rusts, Downy mildews, Powdery mildews, Rusts diseases of wheat, Red rots, Wilt diseases, Paddy blasts, Citrus canker, Bacterial blight of paddy, Angular leaf spot of potato, Tobacco mosaic, Little leaf of brinjal. Significance of plant diseases and control measures. Developing transgenic plants for the resistance against specific crop diseases.

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.
6. P. D. Sharma, 2018, Plant Pathology second Edition, Rastogi publications.

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
4. Study of different diversity indices for community analysis using standard sampling techniques.
5. Study of moisture, water holding capacity, bulk density and porosity of different soil types.
6. Study of some key stone species of Uttarakhand.
7. Visit to any conservation site or community-based biodiversity management committee and report preparation.
8. Identification of diseased plant specimens (Mosaic symptoms, Leaf curling, leaf spots, rust symptoms)
9. Macro and microscopic examination of root nodule bacteria and its isolation.
10. Field visits to observe seasonal / annual disease outbreaks.

BE-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. Ayensu, E.S., Heywood, V.H. and Lucas G.L. 1984. Our green and living world: The wisdom to save it. Cambridge Univ. Press. Cambridge.
2. 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.
3. Bellamy, R. 1993. Ethnobotany in Tropical forests: expedition in field techniques, Royal Geographic Society of London.
4. Berlin, B. 1992. Ethnobiological Classification: Principles and categorization of plants and animals in traditional societies. Princeton Univ. Press. Princeton.
5. 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.

DSElective Lab-III: BEL-03 (BE-03A)**[Credits -2]**

1. Food crops: wheat, rice, maize, chickpea, potato, tapioca, 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.
4. Vegetable oils: Mustard, groundnut, soybean, coconut, sunflower and castor. Morphology, microscopic structure of oil yielding tissues, test for oil and iodine number.

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. **Palaeopalynology:** Introductory idea about palaeopalynological remains, significance of palaeopalynology.
8. **Forensic palynology:** Definition and significance, a few well-known case studies.
9. **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.
10. Breeding systems, self-incompatibility and compatibility control with reference to pollen- pistil interactions and pollen biotechnology.

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. Essentails of Palynology; Asia Publication House Lucknow.
5. Woodhouse, R.P. 1935. Pollen Grains: Hafner Publication Co.

Elective Lab-III: BEL-03 (BE-03B)

[2 Credits]

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.
4. Morpho-anatomical study of stigma and style, Study of the growth of pollen tube through stigma and style.

M.Sc. Botany IVth Semester

Core-X: DSC-10 Modern Approaches in Plant Taxonomy

[5 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.
5. Stace, C. A. (1989). *Plant taxonomy and biosystematics* (2nd ed.). Edward Arnold.
6. Radford, A. E. (1986). *Fundamentals of plant systematics*. Harper & Row

Unit 1: Shoot development: organization of the shoot apical meristem (SAM), cytological and molecular analysis of SAM; root development: organization of root apical meristem (RAM), differentiation of vascular tissue, lateral roots, root hairs; Leaf growth and differentiation: Origin, development and phyllotaxy.

Unit 2: Vascular cambium, its structure, origin and function, cambial activity and factors affecting it; cessation of cambium activity; role of auxins, gibberellins, cytokinins, and ethylene; effect of light and temperature on plant development.

Unit 3: Seed germination and seedling growth, Mobilization of food reserves, tropisms, hormonal control of seedling growth; meristems, shoot development: organization of the shoot apical meristem (SAM), root development: organization of root apical meristem (RAM), vascular tissue differentiation, lateral roots, root hairs, root-microbe interactions.

Unit 4: Role of cambium in healing of wounds; Leaf growth and differentiation: Origin, development and phyllotaxy. Developmental differences between bryophytes, pteridophytes, gymnosperms and angiosperms; Evolution of floral structures: Insights from palaeobotany and molecular genetics.

Recommended Books:

1. Ueli Grossniklaus, 2019. Plant Development and Evolution (Current Topics in Developmental Biology Book 131) 1st Edition, Kindle Edition, Academic Press, USA.
2. Ottoline Leyser, Stephen Day, 2002. Mechanisms in Plant Development, Wiley-Blackwell, pp. 256
3. Raghavan. V. 2000. Developmental Biology of Flowering Plants, Springer Nature, 1st Edition
4. Lalit M. Srivastava, 2002. Plant Growth and Development: Hormones and Environment, Elsevier Academic Press, 1st Edition, pp. 772.

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.

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
6. Histological zonation studies on Shoot and Root Apical Meristems of developing tissues. Effect of plant hormones on growth patterns.
7. Demonstration of Plant tissue culture techniques such as callus production, multiple shoot induction and somatic embryogenesis.
8. Demonstration of initiation and maintenance of plant suspension cell culture.
9. Isolation and purification of algal cultures, Cultivation using different culture media
10. Microscopic identification of microalgae & Biomass estimation
11. Pigment extraction and analysis and Lipid estimation
12. Operation of a laboratory-scale photobioreactor
13. Wastewater treatment using algae

BE-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. Misra, R. Ecology Work Book. Oxford & IBH Publishing Co. New Delhi.
3. Mishra, R. and Gopal, B. Recent Advances in Tropical Ecology: Part I & II. International Society for Tropical ecology, Varanasi.
4. Negi, S.S. 1983. Forest Ecology. Bishen Singh Mahendra Pal Singh, Dehradun.
5. Puri, G.S., Gupta, R.K., Meher-Homji, V.M. and Puri, S. 1989. Forest Ecology: PlantForm, Diversity, Communities and Succession. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
7. Puri, G.S., Meher-Homji, V.M., Gupta, R.K. and Puri, S. Forest Ecology: Vol I & II. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Elective Lab-IV: BEL-04 (BE-04A)

[Credits: 2]

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. Calculate the Pateron week index of any natural forest stand.
5. Study ordination and continuum of different forest stands.
6. Study interspecific Association in forest stands using Plot less technique.
7. Calculate analytical and synthetic characters of different forest stands.
8. Prepare profile diagram of forest stands using Single Plot Method.

BE-04B: Botanical Perspectives in Organic Farming

[4 Credits]

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.

Elective Lab-IV: BEL-04 (BE-04B)

[2Credits]

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.