

UNIVERSITY OF DELHI

DEPARTMENT : BOTANY

COURSE NAME: B.Sc (Hons)

(SEMESTER – 1)

based on
Undergraduate Curriculum Framework 2022 (UGCF)
(Effective from Academic Year 2022-23)



University of Delhi

List of DSC Papers

Course Title	Nature of the Course	Total Credits	Components			Eligibility Criteria/ Prerequisite	Contents of the course and reference is in
			Lecture	Tutorial	Practical		
Plant Diversity and Evolution	DSC- 1	4	2	0	2	10+2 from any recognized Board with Biology & Candidates must appear in CUET in the following subject combination: Physics + Chemistry + Biology/ Biotechnology Merit will be based on the CUET scores obtained in the above-mentioned subjects.	Annexure-I
Cell Biology: Organelles and Biomolecules	DSC- 2	4	2	0	2		Annexure-II
Basic Laboratory and Field Skills in Plant Biology	DSC-3	4	2	0	2		Annexure-III

List of GE Pool 1 Papers (to be offered in odd semester)

Course Title	Nature of the Course	Total Credits	Components			Eligibility Criteria/ Prerequisite	Contents of the course and reference is in
			Lecture	Tutorial	Practical		
Plant Diversity and Human Welfare	GE-01	4	2	0	2		Annexure-IV
Biofertilizers	GE-02	4	2	0	2		Annexure-V
Protected Agriculture – Hydroponics and Organic Cultivation	GE-03	4	2	0	2		Annexure-VI
Basic Laboratory and Field Skills in Plant Biology	GE-04						Annexure-VII
Green Belt Development and Urban Management for Smart Cities	GE-05						Annexure-VIII

Course Code: BOT DSC 01
Course Title: Plant Diversity and Evolution
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Lectures 30, Practical 60

Objective:

To make students aware about the diversity of plants and microbes present on the planet and how are they possibly related to each other in light of evolution.

Learning Outcomes:

This course will impart basic knowledge on

- the diversity of plants and microbes
- their general characteristics
- various groups of plants and their evolutionary relationships
- basic principles and concepts of evolution that contribute to plant diversity

Unit 1: Origin of life

Lectures: 03

Principles and concepts of evolution, Tree of Life, and classification (up-to six kingdoms)

Unit 2: Bacteria

Lectures: 02

General characteristic features, cell structure, asexual reproduction and modes of gene transfer (conjugation, transformation and transduction), brief introduction to Archaeobacteria.

Unit 3: Viruses

Lectures: 02

General characteristic features, replication, RNA virus (structure of TMV), DNA virus (structure of T-phage), Lytic and Lysogenic life cycle (Lambda phage).

Unit 4: Algae

Lectures: 03

General characteristic features, cell structure, range of thallus, methods of reproduction and evolutionary classification (only upto groups). Brief account of *Spirogyra*, *Sargassum*.

Unit 5: Fungi**Lectures: 04**

General characteristic features, reproduction and broad classification. Myxomycetes and their similarities with fungi, plants and animals, Brief account of *Rhizopus*, *Agaricus*. Introduction to lichens

Unit 6: Bryophytes**Lectures: 04**

General characteristic features and reproduction, adaptation to land habit, broad classification, evolutionary trends in Bryophytes. Brief account of *Marchantia*, *Funaria*.

Unit 7: Pteridophytes**Lectures: 04**

General characteristic features and reproduction, broad classification, evolutionary trends in Pteridophytes, affinities with Bryophytes. Brief account of *Adiantum*, *Selaginella*.

Unit 8: Gymnosperms**Lectures: 04**

General characteristic features and reproduction, broad classification, evolutionary trends in Gymnosperm, affinities with Pteridophytes. Brief account of *Gnetum*, *Ephedra*.

Unit 9: Angiosperms**Lectures: 04**

General characteristic features and reproduction, Concept of natural, artificial and phylogenetic system of classification. Affinities with Gymnosperms.

Practicals:

1. To study structure of TMV and Bacteriophage (electron micrographs/models).
2. To study morphology of *Volvox*, *Oedogonium*, *Chara*, *Fucus* and *Polysiphonia* (Temporary preparation/specimens/slides).
3. To study *Rhizopus*, *Penicillium*, *Alternaria* (Temporary preparations), symptoms of rust of wheat, white rust of crucifer (specimen).
4. To study *Marchantia* (morphology, WM of rhizoids and scales), *Anthoceros* (morphology), *Sphagnum* (morphology, WM of leaf), *Funaria* (morphology WM of rhizoid and leaf).

5. To study *Selaginella* (morphology, WM of strobilus and spores), *Equisetum* (morphology, WM of spores), *Pteris* (morphology, tease mount of sporangia and spores).
6. To study *Cycas* (morphology, leaf, leaflet anatomy, coralloid root, bulbils, megasporophyll and microsporophyll); *Pinus* (morphology of dwarf shoot, needle anatomy, male and female cones, WM pollen grains).
7. To study variation in leaf venations in dicots and monocots (at least two specimens each).
8. To study the types of inflorescences in angiosperms (through specimens).
9. To study the types of fruits in angiosperms (through specimens).

Suggested Readings:

1. Campbell, N.A., Reece, J. B. (2008) Biology, 8th edition, Pearson Benjamin Cummings, San Francisco.
2. Evert, R.F., Eichhorn, S.E. (2012). Raven Biology of Plants, 8th edition, New York, NY: W.H. Freeman and Company.
3. Bhatnagar, S.P., Moitra, A. (1996). Gymnosperms. New Delhi, Delhi: New Age International (P) Ltd Publishers.
4. Kumar, H.D. (1999). Introductory Phycology, 2nd edition. Delhi, Delhi: Affiliated East-West. Press Pvt. Ltd.
5. Pelczar, M.J. (2001). Microbiology, 5th edition. New Delhi, Delhi: Tata McGraw-Hill Co.
6. Puri, P. (1985). Bryophytes. New Delhi, Delhi, Atma Ram and Sons.
7. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and Their Allies. (2nd Edition), Medtech Publishers, Delhi.
8. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. San Francisco, U.S.A: Pearson Benjamin Cummings.
9. Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. New Delhi, Delhi: S. Chand & Co Ltd.

10. Singh, G. (2019) Plant Systematics- An Integrated Approach. 4th edition. CRC Press, Taylor and Francis Group.
11. Blackmore, S., Crane, P. (2019) How Plants Work – Form, Diversity, Survival, Princeton University Press; Illustrated edition
12. Ingrouille, M., Eddie, B. (2006) Plants: Evolution and Diversity. Cambridge University Press.

Additional Resources:

1. Parihar, N.S. (1991). An Introduction to Embryophyta. Vol. II. Pteridophytes. Prayagraj: U.P.: Central Book Depot.
2. Singh, V., Pandey, P.C., Jain, D.K. (2001). A Text Book of Botany. Meerut, UP: Rastogi and Co.
3. Webster, J., Weber, R. (2007). Introduction to Fungi. Cambridge, Cambridge University Press.

Keywords: Evolution, Bacteria, Viruses, Bryophytes, Pteridophytes, Gymnosperms, Angiosperms

Course Code: BOT DSC 02
Course Title: Cell Biology: Organelles and Biomolecules
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Lectures 30, Practical 60

Objectives:

The course will help students gain knowledge about:

- cell as a structural and functional unit of life.
- types of biomolecules (proteins, carbohydrates, lipids and nucleic acids) and their roles in cell structure and function.
- structures of different organelles and their role in fundamental metabolic processes of a cell.

Learning Outcomes:

This course will be able to demonstrate basic knowledge and understanding of

- the relationships between the properties of macromolecules, their cellular activities and biological functions.
- physico-chemical composition of organelles and their functional organization.

Unit 1: Biomolecules

Lectures: 10

Types of chemical bonds and their biological significance. Structure and biological roles of carbohydrates, lipids, proteins and nucleic acids. ATP: structure and its role as an energy currency molecule.

Unit 2: The Cell

Lectures: 02

Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).

Unit 3: Cell Wall and Plasma Membrane

Lectures: 03

Chemistry, structure and function of Plant Cell Wall. Singer and Nicolson's fluid mosaic model of cell membrane.

Unit 4: Cell Organelles: Structure and function of the following organelles

Lectures: 11

Nucleus: Structure and function (nuclear envelope, nuclear pore complex, nuclear lamina); types of chromatins; nucleolus.

Chloroplast and Mitochondria: Structural organization; Function; Semi-autonomous nature of mitochondria and chloroplast.

Endomembrane system: Endoplasmic Reticulum – Structure and function of RER and SER, protein folding, processing in ER, export of proteins and lipids; Golgi Apparatus Organization, protein glycosylation, protein sorting and export from Golgi Apparatus. Introduction to post- translational modifications.

Peroxisome and Lysosomes: Structure and function.

Cytoskeleton: Role and structure of microtubules, microfilaments, intermediary filament and motor proteins.

Unit 5: Cell division

Lectures: 04

Eukaryotic cell cycle, mitosis and meiosis; regulation of cell cycle.

Practicals:

1. Study of cell and its organelles with the help of electron micrographs and other digital resources.
2. Study of plant cell structure with the help of epidermal peel mount of *Allium/Rhoeo/Crinum*.
3. Microchemical tests for carbohydrates (reducing, non-reducing sugars and starch), lipids and proteins.
4. Separation of chloroplast pigments by paper chromatography/Thin Layer Chromatography.
5. Separation of amino acids by paper chromatography.

6. Study the effect of organic solvent and temperature on membrane permeability.
7. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
8. Demonstration of the phenomenon of plasmolysis and deplasmolysis.
9. Demonstration of separation of biomolecules by dialysis.

Suggested Readings:

1. Hardin, J. and Lodolce, J.P. (2022). Becker's World of the cell, 10th edition, Pearson
2. Berg, J.M., Tymoczko, J.L., Stryer, L. (2011). *Biochemistry*. New York, NY: W. H. Freeman and Company.
3. Campbell, N. A. (2020). Biology: A Global Approach, 12th Edition, Pearson
4. Campbell, P.N., Smith, A.D. (2011). *Biochemistry Illustrated*, 4th edition. London, UK: Churchill Livingstone.

Additional Resources:

1. Cooper, G.M., Hausman, R.E. (2019). The Cell: A Molecular Approach, 7th edition. Sinauer/OUP.
2. Iwasa, J, Marshall , W. (2020). Karp's Cell Biology, 9th edition, New Jersey, U.S.A.: John Wiley & Sons.
3. Majumdar, R., Sisodia, R. (2019). Laboratory Manual of Cell Biology, with reference to Plant Cells. New Delhi, Delhi: Prestige Publication.
4. Nelson, D.L., Cox, M.M. (2021). Lehninger Principles of Biochemistry, 8th edition. New York, NY: W.H. Freeman and Company.
5. Reven, F.H., Evert, R.F., Eichhorn, S.E. (1992). Biology of Plants. New York, NY: W.H.Freeman and Company.
6. Tymoczko, J.L., Berg, J.M., Stryer, L. (2012). Biochemistry: A short course, 2nd edition. New York, NY: W.H.Freeman and Company.

Keywords: Proteins, lipids, carbohydrates, nucleic acids, plasma membrane, endomembrane system, cell organelles, cytoskeleton, mitosis and meiosis

Course Code: BOT DSC 03
Course Title: Basic Laboratory and Field Skills in Plant Biology
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Lectures 30, Practical 60

Objective:

To learn fundamental skills important for performing laboratory and field experiments

Learning Outcomes:

- Good laboratory practices, management of laboratory waste, understanding hazards and risks to ensure a safe laboratory environment.
- Basics of measurements, units and common mathematical calculations, sampling and data collection.
- Operation and maintenance of instruments
- Presentation, analysis of data and interpretation of results.

Unit 1: Lab safety and good lab practices

Lectures: 04

General laboratory safety, good laboratory practices, biosafety measures (first-aid practices to be followed in case of burn, acid spills and injury), safety symbols, lab safety equipments (fire extinguisher, fume hood, safety glasses), classes of laboratory chemicals, maintenance and handling of chemicals (Labels, Quality - LR/ AR/ Molecular biology grade/ HPLC grade; Expiry date; Precautions for use), Disinfectants, Biocontainment, Disposal of hazardous chemicals, radioactive and biological waste, Laboratory waste management.

Unit 2: Use and maintenance of Laboratory equipment

Lectures: 04

Weighing balance (Top loading and Analytical), pH meter (calibration and use), magnetic stirrer, pipettes and micropipettes, autoclave, laminar airflow, BOD incubator, incubator shaker, micrometer, haemocytometer, spectrophotometer, Agarose gel electrophoresis unit, SDS PAGE unit, centrifuge, distillation unit, conductivity meter, Lux meter.

Unit 3: Microscopy, sample and slide preparation

Lectures: 05

Microscopes (Dissecting, Compound and Electron microscopes), Fixation and Preservation (for light and electron microscopy); staining, mounting; basic introduction to other types of microscopes (Confocal, Fluorescence)

Unit 4: Measurements and calculations**Lectures: 02**

Units of measurements and conversion from one unit to another, measurement of volumes of liquids, Weighing, calculations: scientific notations, powers, logarithm and fractions.

Unit 5: Solutions and Buffers**Lectures: 02**

Molarity, Molality, Normality, percent solution, stock solution, standard solution, dilution, dilution series, pH, acids and bases, buffers - phosphate, Tris- acetate, Tris-Cl and Citrate buffer.

Unit 6: Basic culturing techniques**Lectures: 03**

Basic culture media (LB, YEB, MS)- liquid and solid, Culture techniques: plating (streak, spread & pour), replica plating, serial dilution.

Unit 7: Data collection, statistical analysis and interpretation**Lectures: 04**

Fundamentals of data collection, data types - primary and secondary, methods of data collection, sample, sampling methods - merits and demerits, technical and biological replicates, classification - tabulation and presentation of data, Descriptive statistics - Mean, Mode, Median, Variance, Standard Deviation, Standard error, Coefficient of Variation, difference between sample mean and population mean.

Unit 8: Basic computer skills for biology**Lectures: 04**

MS-Word, PowerPoint, Excel, introduction to biological databases.

Unit 9: Field Skills**Lectures: 02**

Identification, collection, cataloguing and preservation of plant specimens, Herbarium and Museum.

Practicals:

1. Preparation of solutions- molar, molal, normal, percentage, stock, standard and serial dilution
2. Determining pH of solutions (pH paper, Universal indicator, pH meter) and preparation of buffers (Phosphate, Tris-Cl, Electrophoresis buffers - TBE/TAE)
3. Working of instruments -light microscope, autoclave, laminar air flow, spectrophotometer, centrifuge, gel electrophoresis unit (Agarose & Poly acrylamide).

4. Temporary peel mount slide preparation and staining (safranin and acetocarmine).
5. Calculate cell size using micrometer.
6. Calculate number of cells (pollen/spores) using haemocytometer.
7. Preparation of LB medium, growth and maintenance of bacterial cultures (liquid - serial dilution method; and semi-solid cultures - streak, spread and pour plates)
8. Isolation of genomic DNA from *E. coli* and plant leaf material, Agarose gel electrophoresis
9. Calculation of mean, mode, median, standard deviation using data set (collected from experiments 5,6).
10. Using software to draw tables, graphs and calculating descriptive statistics (Microsoft Excel)
11. Laboratory safety equipment (Fire extinguisher, Fume hood, safety glasses)
12. Mounting of a properly dried and processed plant specimen with herbarium label.

Suggested Readings:

1. Evert, R. F., Eichhorn, S. E., Perry, J.B. (2012). Laboratory Topics in Botany. W.H. Freeman and Company.
2. Mesh, M.S., Kebede-Westhead, E. (2012). Essential Laboratory Skills for Biosciences. John Wiley & Sons, Ltd.
3. Mu, P., Plummer, D. T. (2001). Introduction to practical biochemistry. Tata McGraw-Hill Education.
4. Mann, S. P. (2016). Introductory Statistics, 9th edition. Hoboken, NJ, John Wiley and Sons Inc.
5. Danniel, W.W. (1987). Biostatistics. New York, NY: John Wiley Sons.
6. Jones, A.M., Reed, R., Weyers, J. (2016). Practical Skills in Biology, 6th Edition, Pearson
7. Bisen, P.S. (2014). Laboratory Protocols in Applied Life Sciences, 1st edition. CRC Press.

Additional resources:

1. Zar, Z. H. (2010). Biostatistical Analysis, 5th edition, Pearson Prentice Hall, New Jersey, USA.

Keywords: Solutions, buffers, stains, medium preparation, Laboratory safety and maintenance.

Course Code: BOT GE 01
Course Title: Plant Diversity and Human Welfare
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Lectures 30, Practical 60

Objective:

Build awareness about the different groups of plants and their roles in supporting human life.

Learning outcomes:

This course will be able to impart basic knowledge in understanding:

- the diversity of various groups of plants, their characteristics and identification.
- different phytogeographic zones in India.
- the basic principles of conservation of Biodiversity and Sustainable Development Goals (SDG).
- the role of plants in human welfare.

Unit 1: Understanding biodiversity

Lectures: 06

Understanding biodiversity - definition of key terms; plant diversity in India; assigning value to plant diversity; economic and ecological importance of algae, bryophytes, pteridophytes and gymnosperms; insights into flowering plant diversity with special focus on agrobiodiversity.

Unit 2: Crop diversity

Lectures: 08

Crop diversity in various phytogeographic regions in India and their traditional importance as food (including cereals, pulses, oil crops, spices, beverages, fruits and nuts, vegetables, condiments), medicines (Ashwagandha and Sarpagandha) and adornments.

Unit 3: Role of forests**Lectures: 06**

Forests, woodlands, and vegetation stands: diversity and their importance in ecological, aesthetic, and overall well-being; social dimensions of plant diversity; commercial value and utilization of plant wealth.

Unit 4: Cash Crops**Lectures: 05**

Crops of high economic value (tobacco, sugarcane, cotton, basmati rice, sandalwood, saffron); Petro crops: the future industry (*Jatropha* sp., corn and sugarcane).

Unit 5: Conservation of biodiversity**Lectures: 03**

Conservation of biodiversity using community driven conservation strategies, sustainable utilization keeping Sustainable Development Goals (SDGs) in mind, Innovative approaches and traditional methods of biodiversity utilization and waste minimization during product formation.

Unit 6: Policy issues in conservation of Biodiversity**Lectures: 02**

National and International initiatives and programmes/schemes focussing on Plant Diversity and human welfare (Tribal Rights Bill, Convention on Biological Diversity (CBD), International Union for Conservation of Nature (IUCN), Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA).

Practicals:

1. To study local plant diversity (common algae, bryophytes, pteridophytes, gymnosperms (any two of each) in and around the campus; and understand their ecological and economic importance.
2. Microchemical tests for carbohydrates, proteins and oils.
3. To study (any three) commonly found tree species in the vicinity and understand their role in human welfare.
4. To prepare an inventory of common medicinal plants in your campus (identify to the family level, list their uses in Indian System of Medicines)
5. To visit the local parks and list the trees planted. Also assess some for their dust pollution mitigation capacity using standard procedures.

6. Industrial visit to see how the drugs are extracted from plants (report to be submitted for evaluation).

Suggested Readings:

1. Bilgrami, K. S. (1998). *Phytodiversification and Human Welfare: Dedicated to Late Prof. KS Bilgrami, FNA (1933-96)*. MD Publications Pvt. Ltd.
2. Utting, P. (2013). *Trees, People and Power*. Routledge.
3. Manoharachary, C., Nagaraju, D. (2016). Medicinal plants for human health and welfare. *Ann. Phytomed*, 5(1), 24-34.
4. Myers, N. (2019). *A wealth of wild species: storehouse for human welfare*. Routledge.

Keywords: Plant, Diversity, Agrobiodiversity, Human Welfare

Course Code: BOT GE 02
Course Title: Biofertilizers
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Lectures 30, Practical 60

Objectives:

- To develop an understanding of biological systems used as fertilizers and build skills in handling microbial inoculants.
- To understand the optimum conditions for growth and multiplication of useful microbes such as *Rhizobium*, cyanobacteria, mycorrhizae, *Azotobacter* etc.
- To understand the role of microbes in mineral cycling and nutrition of plants.
- To gain expertise in various methods of decomposition of biodegradable waste, conversion into compost and apply this knowledge and skill in their daily life.

Learning Outcomes:

On successful completion of this course, a student will be able to:

- visualize and identify different types of microorganisms with a compound microscope.
- understand the classification of microorganisms according to their shape/ structure for morphological identification. Prepare and sterilize different types of culture media.
- isolate of microorganisms from the environmental samples and culture in aseptic conditions.

Unit 1: Introduction

Lectures: 07

Introduction to microbial inoculants or biofertilizers, macro and micro nutrition of plants, chemical fertilizers versus biofertilizers; Methods and steps in mass multiplication of biofertilizers: stock culture, broth culture, growth medium, fermentation, blending with the carrier, packaging, and quality check, ISI standard specification for biofertilizers; scope of biofertilizers in India.

Unit 2: Microbial Inoculants**Lectures: 08**

Study of important microbial inoculants: *Rhizobium*, *Azospirillum*, *Azotobacter*, Actinorhizae; Characteristics, isolation, identification, and crop response.

Unit 3: Role of Cyanobacteria**Lectures: 02**

Role of Cyanobacteria (blue-green algae) in rice cultivation; *Azolla* and *Anabaena azollae* association, nitrogen fixation, and factors affecting growth.

Unit 4: Mycorrhizal association**Lectures: 08**

Types of mycorrhizal association, taxonomy, occurrence and distribution; Role of Arbuscular mycorrhizal fungi in phosphorus nutrition, growth and yield of crop plants; AMF – methods in isolation (wet sieving and decanting), identification (morphological and molecular methods). Methods of inoculum production (Pot culture and root culture).

Unit 5: Organic farming**Lectures: 05**

Introduction to organic farming, recycling of biodegradable municipal (domestic), agricultural and industrial waste; green manuring, bio-composting, vermicomposting and their field application.

Practicals:

1. Study of *Rhizobium* from root nodules of leguminous plants by Gram staining method.
2. Observation of arbuscular mycorrhizal fungi from plant roots.
3. Isolation of arbuscular mycorrhizal spores from rhizosphere soil.
4. Isolation of *Anabaena* from *Azolla* leaf.
5. Study of Earthworm, *Azolla*, AMF: Arbuscules-vesicles through specimen / digital resources.
6. Study of Biocontrol methods and their application -Pheromone trap, *Trichoderma*, *Pseudomonas*, Neem etc. through digital resources.
7. Rapid test for pH, NO_3^- , SO_4^{2-} , Cl^- and organic matter of different composts.
8. Projects on any one of the following topics: *Rhizobium* technology, AMF technology, Organic farming, Bio composting, Vermicomposting, *Azolla* culture

etc. (The design of the project should be such that it includes a continuous work of at least 6 weeks and a dissertation submission).

Suggested Readings:

1. Kumaresan, V. (2005). Biotechnology. New Delhi, Delhi: Saras Publication.
2. Sathe, T.V. (2004). Vermiculture and Organic Farming. New Delhi, Delhi: Daya publishers.
3. Subha Rao, N.S. (2020). Soil Microbiology, 5th edn. New Delhi, Delhi: Oxford & IBH Publishers.
4. Reeta Khosla (2017). Biofertilizers and Biocontrol Agents for Organic Farming, Kojo Press

Additional Resources:

1. *Azotobacter* - Isolation and characterization - <https://youtu.be/1Z1VhgJ2h6U>
2. *Rhizobium* - Identification and characterization - <https://youtu.be/jELlo-pMvc4>.
3. 3-Days Online Workshop On Arbuscular Mycorrhizal Fungi - Biodiversity, Taxonomy and Propagation 19-2 (2022-01-20 at 02_27 GMT-8) - <https://youtu.be/LKzK4IuSRc4>.
4. Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming. Nadiad, Gujarat: Akta Prakashan.

Keywords: *Rhizobium*, *Azotobacter*, inoculum, cyanobacteria, nitrogen fixation, *Azolla*, mycorrhizae

Course Code: BOT GE 03
Course Title: Protected Agriculture - Hydroponics and Organic Cultivation
Total Credits: 04 (Theory 02, Practical 02)
Total Hours: Lectures 30 Practical 60

Objectives:

- To provide knowledge and expertise of various aspects of hydroponics, aquaponics and organic cultivation to the students.
- To make students economically self-reliant by growing and marketing organic herbs, vegetables, microgreens and fruits.

Learning Outcomes:

- Students will develop a thorough understanding of the concept of Hydroponics, Aquaponics and Organic farming.
- Students will be trained in establishing hydroponic facility³. Students will learn the development of various organic products such as biopesticides, biofertilizers and biogrowth promoters.
- Students will understand various government policies in marketing of hydroponic and organic produce.
- Understand Good Agricultural Practices associated with protected agriculture.

Unit 1: Introduction to Protected Agriculture

Lectures: 02

Protected Agriculture types (hydroponics, aquaponics and organic farming), definition history, terminology, importance and advantages over traditional agriculture, limitations and challenges.

Unit 2: Plant Growth Requirements and Media formulations

Lectures: 05

Physical parameters - light (quality and quantity) artificial light, light balancers; pH, conductivity, salinity (Dissolved Oxygen-DO, Total Dissolved Solid - TDS) and temperature; Chemical parameters- mineral nutrient requirements, deficiencies, toxicities, growth regulators (auxins, gibberellins, cytokinins and abscisic acids); Growth media- types, properties, uses, nutrient formulae, preparation of solutions, solid Media and nutrient film.

Unit 3: Hydroponic growing systems**Lectures: 07**

Basic concepts and designs (closed and open systems techniques Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket and other small-scale systems), systems layout. Strengths and weaknesses of various systems, site considerations, componentry, nutrient delivery, pumping

Unit 4: Hydroponics associated pest and diseases**Lectures: 06**

Hydroponics associated pest - mites, thrips, whiteflies, leaf miners; Identification and management of diseases -bacterial, fungal and viral diseases; safety practices (Good Agricultural Practices (GAP) and Integrated Pest Management (IPM)).

Unit 5: Organic farming and its management**Lectures: 06**

Organic farming and associated management practices (nutritional requirements, pest, diseases, weeds); use of biofertilizers, biopesticides, bioherbicides, biocontrol agents (plant growth promoting rhizobacteria (PGPR), pheromone trapping, *Trichoderma*, *Pseudomonas*, neem oil, garlic etc.) in management.

Unit 6: Marketing and Policies**Lectures: 04**

Marketing of the produce and government institutes and policies related to protected farming (hydroponics and organic farming).

Practicals:

1. Study of various instruments used in hydroponics.
2. Preparation of growth media for hydroponics.
3. Estimation of NPK, DO, TDS, pH of growing media
4. Demonstration of different irrigation techniques in hydroponics.
5. Demonstration of construction of a sustainable hydroponic unit.
6. Perform rapid tests for estimation of NPK in different soil samples (at least three).
7. Bulk density and porosity of soilless media e.g. coco-peat, perlite, vermiculite, expanded clay, rockwool (any two media).
8. Demonstration of growing a leafy vegetable/fruity vegetable/ medicinal

herb/aromatic plant in Hydroponics solution.

9. Study of traditional organic inputs and formulation of biofertilizer.
10. Preparation of biopesticides, plant health promoters like *Panchgavya*, *Beejamrut* etc.
11. Field visit to organic farm/hydroponic farm and submission of visit report.

Suggested Readings:

1. Schwarz, M. (1995). Soilless Culture Management. Advanced Series in Agricultural Sciences, vol. 24. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-79093-5_2.
2. Hasan, M., Sabir, N., Singh, A.K., Singh, M.C., Patel, N., Khanna, M., Rai, T., Pragnya, P. (2018). Hydroponics Technology for Horticultural Crops, Tech. Bull. TB-ICN 188/2018. Publ. by I.A.R.I., New Delhi-110012 INDIA.
3. Misra S., Misra S., Misra R.L. (2017). Soilless Crop production. Daya Publishing House, Astral International (P) Ltd., New Delhi.
4. Palaniappan S. P., Annadurai K. (2018). Organic Farming: Theory & Practice. Scientific Publisher.
5. Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (2019). Aquaponics Food Production Systems. Springer, Cham.

Additional Resources:

1. Jones, J. B. (2014). Complete Guide for Growing Plants Hydroponically. CRC Press.
2. Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming. Akta Prakashan, Nadiad.

Keywords: hydroponics, aquaponics, organic farming, Dissolved Oxygen-DO, Total Dissolved Solid – TDS, Good Agricultural Practices (GAP) and Integrated Pest Management (IPM), Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket .

Course Code: BOT GE 04
Course Title: Basic Laboratory and Field Skills in Plant Biology
Credits : 04 (Theory 02, Practical 02)
Total Hours: Lectures 30, Practical 60

Objective:

To learn fundamental skills important for performing laboratory and field experiments.

Learning Outcomes:

- Good Lab Practices, management of laboratory waste, understanding hazards and risks to ensure a safe laboratory environment.
- Basics of measurements, units and common mathematical calculations, sampling and data collection.
- Handling and maintenance of instruments
- Presentation, analysis and interpretation of results.

Unit 1: Lab safety and good lab practices

Lectures: 04

General laboratory safety, good laboratory practices, biosafety measures (first-aid practices to be followed in case of burn, acid and injury), safety symbols, lab safety equipments (Fire extinguisher, fume hood, safety glasses), classes of laboratory chemicals, maintenance and handling of chemicals (Labels, Quality - LR/ AR/ Molecular biology grade/ HPLC grade; Expiry date; Precautions for use), Disinfectants, Biocontainment, Disposal of hazardous chemicals, radioactive and biological waste, Laboratory waste management

Unit 2: Use and maintenance of Laboratory equipments

Lectures: 04

Weighing balance (Top loading and Analytical), pH meter (calibration and use), magnetic stirrer, pipettes, autoclave, laminar airflow, BOD incubator, incubator shaker, micrometer, haemocytometer, spectrophotometer, Agarose gel electrophoresis unit, SDS PAGE unit, centrifuge, distillation unit, conductivity meter, Lux meter.

Unit 3: Microscopy, sample and slide preparation:

Lectures: 05

Microscopes (Dissecting, compound, electron microscope), Fixation and Preservation (for light and electron microscopy); staining, mounting; basic introduction to other types of microscopes (confocal, fluorescence)

Unit 4: Measurements and calculations**Lectures: 02**

Units of measurements and conversion from one unit to another, measurement of volumes of liquids, Weighing, calculations: scientific notations, powers, logarithm and fractions

Unit 5: Solutions and Buffers**Lectures: 02**

Molarity, Molality, Normality, percent solution, stock solution, standard solution, dilution, dilution series, pH, acid and bases, buffers- Phosphate, Tris- acetate, Tris-Cl and Citrate buffer

Unit 6: Basic culturing techniques**Lectures: 03**

Basic culture media (LB, YEB, MS)- Liquid and solid, Culture techniques : plating (streak, spread & pour), replica plating , serial dilution

Unit 7: Data collection, statistical analysis and interpretation**Lectures: 04**

Fundamentals of data collection, data types - primary and secondary, methods of data collection, sample, sampling methods - merits and demerits, technical and biological replicates, classification - tabulation and presentation of data, Descriptive statistics - Mean, mode, median, Variance, Standard Deviation, Standard error, Coefficient of Variation, difference between sample and population mean.

Unit 8: Basic computer skills for biology**Lectures: 04**

MS- Word, PowerPoint, Excel, introduction to biological databases

Unit 9: Field Skills**Lectures: 02**

Identification, collection, cataloguing and preservation of plant specimens, Herbarium and Museum

Practicals:

1. Preparation of solution- molar, molal, normal, percentage, stock, standard and serial dilution
2. Determining pH of solutions (pH paper, Universal indicator, pH meter) and preparation of buffers (Phosphate, Tris-Cl, Electrophoresis buffers- TBE/TAE)

3. Working of instruments - light microscope, autoclave, laminar air flow, spectrophotometer, centrifuge, gel electrophoresis unit (Agarose & Polyacrylamide gels)
4. Temporary peel mount slide preparation and staining (safranin and acetocarmine).
5. Calculate cell size using micrometer.
6. To calculate number of cells using haemocytometer per unit volume (using pollen/spores)
7. Preparation of LB medium, growth and maintenance of bacterial cultures (liquid - serial dilution method; and semi-solid cultures - streak, spread and pour plates)
8. Isolation of genomic DNA from *E. coli* and plant leaf material, Agarose gel electrophoresis.
9. Calculation of mean, mode, median, standard deviation using data set (collected from experiments 5,6).
10. Using software to draw tables, graphs and calculating descriptive statistics (Microsoft Excel)
11. Laboratory safety equipments (Fire extinguisher, Fume hood, safety glasses)
12. Mounting of a properly dried and processed plant specimen with herbarium label

Suggested Readings:

1. Evert, R. F., Eichhorn, S. E., Perry, J.B. (2012). Laboratory Topics in Botany. W.H. Freeman and Company.
2. Mesh, M.S., Kebede-Westhead, E. (2012). Essential Laboratory Skills for Biosciences. John Wiley & Sons, Ltd.
3. Mu, P., Plummer, D. T. (2001). Introduction to practical biochemistry. Tata McGraw-Hill Education.
4. Mann, S. P. (2016). Introductory Statistics, 9th edition. Hoboken, NJ, John Wiley and Sons Inc.
5. Danniel, W.W. (1987). Biostatistics. New York, NY: John Wiley Sons.
6. Jones, A., Reed, R., Weyers, J. (2016) Practical Skills in Biology, 6th Edition, Pearson.
7. Bisen, P.S. (2014). Laboratory Protocols in Applied Life Sciences (1st edition). CRC Press.

Keywords: Laboratory equipment, Molar solution and buffer preparations.

Course Code: BOT GE 05
Course Title: Green Belt Development and Urban Management for Smart Cities
Total Credits: 04 (Theory 2, Practical 2)
Total Hours: Lectures 30, Practical 60

Objectives:

- Green Belt Development is a major step in the development of a sustainable ecosystem, particularly under the Smart Cities Program for urban development (Government of India).
- To introduce students with one of the key green skill development programs under the Skill India mission by the Government of India.
- To acquaint students with various methods and techniques used in development of green infrastructure for smart cities

Learning Outcomes:

- Course familiarizes students with green skills that contribute to preserving or restoring the environment for a sustainable future that protect ecosystems and biodiversity, reduce energy and minimize waste and pollution.
- This course will help students understand the role of green belt in capturing the transient emissions, prevent soil erosion and degradation, containing water run-offs and recharging ground water, attenuate the noise generated and improve the aesthetics.
- Students would be well trained (knowledge & skills) to contribute to Green Sector Skill program.

Unit 1: Introduction

Lecture: 02

Definition, History and Concept of Green Belt; Aesthetics and Importance; Recommended Guidelines for green belt development for industries; Advantages and Applications.

Unit 2: Pollution and Carbon emission

Lecture: 04

Type and various source of Emissions; Methods of estimation and monitoring of pollutants; Mechanism of deposition; Regulatory standards for major pollutants.

Unit 3: Plant-Pollutant Interaction**Lecture: 04**

Methods of sampling and screening local flora, Native and Exotic Plants, Various indicators (Morphological, Anatomical, Physiological and Biochemical) for selection of pollution mitigating plants; Sensitive/indicator, Resistant/ Tolerant Plant Species for different pollutants (air, water, land and sound). Factors effecting plant regeneration and growth.

Unit 4: Structural and Functional Aspects of Green Belt**Lecture: 06**

Methods of Planting and Propagation, Various approaches for green belt development, Theoretical Models; Site specific ecological requirements, parameters involved that effect landscape design, Methods to evaluate the effectiveness of green belt. Various tools for assessment and monitoring of green belt (GIS and Remote Sensing)

Unit 5: Green Belt for Mitigating Climate change**Lecture: 04**

Objectives of UNFCCC for mitigating greenhouses gases in urban sectors, Green Finance and Green Infrastructure development, Methods to Evaluate total carbon sequestered; Carbon stocks and credits.

Unit 6: Waste water treatment through constructed wetlands**Lecture: 06**

Introduction: Wetlands values and functions, natural and constructed wetlands for wastewater treatments; Life forms in wetlands: microbes and vegetation in wetlands, plants adapted to pollutants and flooding, Role of macrophytes in constructed wetlands; physical and chemical characteristics of freshwater wetlands, constructed wetlands: types, role and management including key parameters for assessment.

Unit 7: Economics of Green Infrastructure**Lecture: 04**

Understanding of key plants for green economy - NFTP (Non-Forest timber products), biodiesel plants, herbal garden; Evaluating the cost and benefits of green belt development with type studies, Environmental accounting, Ecosystem services and constituents of wellbeing. Environmental Impact Assessment

Practicals:

1. Methods of Vegetation Sampling and calculation of importance value index.
2. Measuring Tree Height and Cover to estimate green cover of an area.
3. Estimation of total carbon of an area.
4. Methods for selection of plants according to pollutant load both air and water (includes field survey)
5. Open Sources Software for mapping the GPS points and generating a cover map.
6. Measurement of Dissolved Oxygen (DO) from treated waste water.
7. Measurement of BOD and TDS from intake and treated pond.

Suggested Readings:

1. Vesilind, P. A., Peirce, J. J., Weiner, R., (1998). Environmental Pollution and Control Netherlands: Elsevier Science.
2. Burnwal, K., Jagwani, D. (2013). Air Pollution Abatement through Trees & Green Belt Development. LAP Lambert Academic Publishing.
3. CPCB (2000). Guidelines for Green Belt development, CPCB, MoEF, GoI, New Delhi.
4. Zhou, S. W. W., Zhou, S. W. W. (2020). Carbon Management for a Sustainable Environment. Germany: Springer International Publishing.
5. Yunus, M., Singh, N. de Kok, L.J. (2013). Environmental Stress: Indication, Mitigation and Eco-conservation. Netherlands: Springer Netherlands
6. Acar, S., Yeldan, A.E. (2019). Handbook of Green Economics Netherlands: Elsevier Science.
7. Stefanakis, A., (2018). Constructed Wetlands for Industrial Wastewater Treatment United Kingdom, Wiley.
8. Kröpfelová, L., Vymazal, J., Kröpfelová, L., Vymazal, J. (2008). Wastewater Treatment in Constructed Wetlands with Horizontal Sub-Surface Flow. Czechia: Springer Netherlands.

Keywords: Alkaloids, flavonoids, tannins, terpenoids, saponins and glycosides, Biopiracy, TKDL, Nutritional Ethnobotany, Ethnopharmacology.