CURRICULA AND SYLLABI FOR
MASTER DEGREE PROGRAMMES
IN BASIC SCIENCES

AGRICULTURAL MICROBIOLOGY,
BIOCHEMISTRY, PLANT MOLECULAR
BIOLOGY AND BIOTECHNOLOGY, AND
CROP PHYSIOLOGY

ACCREDITATION BOARD SECRETARIAT
EDUCATION DIVISION
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAWAN-II, PUSA,
NEW DELHI - 110012
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Agricultural education in the broad sense covers all human endeavors in the acquisition, transmission and absorption of knowledge for the better means and understanding of the processes which lead to the scientific farming. Though the present educational system produces graduates with the best knowledge of sciences, the desired emphasis is lacking for the development of skills, attitude, which needs strengthening. Quality manpower alone would compete in the international market. Therefore, it is imperative that our education should be skill as well as commercial oriented, and satisfying the current market demands.

The Indian Council of Agricultural Research, the apex body for the agricultural education is very keen in improving the agricultural education. It has taken several initiatives in improving the agricultural education under the leadership of Dr S.L. Mehta, Deputy Director General (Education) with full support and guidance from Dr R.S. Paroda, Director General, ICAR, New Delhi. As part of the activity, Accreditation Board was constituted to improve and sustain the quality of education in SAUs. National level Third Deans' Committee constituted for reviewing the agricultural education, had recommended constitution of committees for restructuring of PG Programs in Agricultural Sciences. Accordingly, the ICAR constituted 16 Broad Subject Matter Committees (BSMCs) for various subjects, one being in Basic Sciences. Dr S. Kannaiyan, V.C., Tamil Nadu Agricultural University, Coimbatore was nominated as Coordinator for BSMC in Basic Sciences covering Agricultural Microbiology, Plant Molecular Biology and Biotechnology, Biochemistry, and Plant Physiology. Other members of BSMC were Dr R.P. Sharma, Dr M.L. Lodha, Dr K.V.B.R. Tilak, Dr B.S. Parmar and Dr N. Sethunathan, all from IARI, New Delhi; Dr Udaï Kumar, Dr D.J. Bagyaraj, UAS, Bangalore and Dr Randhir Singh, HAU, Hisar.

Dr S. Kannaiyan, Dr R.P. Sharma, Dr M.L. Lodha and Dr Udaï Kumar were identified as leaders to prepare draft syllabi looking to the present syllabi of some of the leading universities in India and abroad in Agricultural Microbiology, Plant Biotechnology, Bio-chemistry and Crop Physiology, respectively.

The identified leaders went through the existing syllabi and restructured the same as per the common academic regulations. The draft syllabi were discussed among BSMC members and were given final touches before being sent to the experts in the concerned field for their comments and suggestions for further improvement. The comments and suggestions
received from the experts on the restructured syllabi were discussed in detail and the final version of the restructured syllabi was prepared. This version was placed in a meeting-cum-workshop which was organized for two days at UAS, Bangalore on 5-6th March, 1999 where syllabi of Plant Biotechnology, Biochemistry and Crop Physiology were finalized. Agricultural Microbiology Syllabus was finalized in another two days workshop organized at TNAU, Coimbatore on 25th -6th September, 2000. The modified syllabi includes courses that have been designed to train postgraduate students to tackle present problems and prepare them for the future. The impact of the rapidly accumulating information due to recent technological advances in biological sciences has been realized in designing the syllabi.

We wish to extend our profound thanks to all the members of the BSMC. Special thanks are due to Dr R.P. Sharma, Project Director, NRC on Plant Biotechnology, Dr M.L. Lodha, Head, Division of Biochemistry, IARI, New Delhi and Dr Udai Kumar, Prof. & Head, Department of Crop Physiology, University of Agricultural Science, Bangalore for their leadership role in the concerned disciplines. Thanks are also due to Dr K. Govindarajan, Prof. & Head, Dr S.P. Sundaram, Prof., Dr K. Kumar and Dr G. Gopalawamy, Associate Professors in the Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore for their active involvement, valuable comments and suggestions in developing the restructured syllabi in Agricultural Microbiology. We specially thank to those who personally participated in the meeting-cum-workshops organized for the purpose, as without their contribution, this exercise would not have become fruitful.

We would like to place on record our gratitude's to Dr S. Bislaiah, the then Vice Chancellor, UAS, Bangalore for hosting the first meeting-cum-workshop at Bangalore.

We hope that this document will help in achieving uniformly high standards of postgraduate education in the concerned disciplines. The Accreditation Board Secretariat will be happy to receive comments and suggestions for improving and updating this publication in future.

S. Kannaiyan
N.L. Maurya
G.D. Diwakar
S.L. Mehta
CONTENTS

Preface (iii)

1. Agricultural Microbiology 1

2. Biochemistry 15

3. Plant Molecular Biology and Biotechnology 27

4. Crop Physiology 40

Annexures

I. List of participants in the meeting-cum-workshop in the BSMA of 55 Basic Sciences 59

II. List of participants in the meeting-cum-workshop in the BSMA of 56 Basic Sciences (Microbiology) 61
1. **AGRICULTURAL MICROBIOLOGY**

## A. MAJOR

### A.1. CORE COURSES 12 CREDITS

1. Fundamentals of microbiology 2 + 1
2. Morphology, cytology and [classification](#) of microorganisms 2 + 1
3. **Microbial** physiology 2 + 1
4. Microbial genetics 2 + 1

Seminar 0+ 1 credit

### A.2. OPTIONAL COURSES 8 CREDITS

1. Microbial ecology 1 + 1
2. Soil microbiology 1 + 1
3. Fermentation technology 1 + 1
4. **B**io**f**ertilizers 1 + 1
5. Food microbiology 1 + 1
6. Microbial management of organic wastes 1 + 1
7. Microbial control of crop pests and diseases 1 + 1

## B. SUPPORTIVE COURSES 14 CREDITS

To be decided by the Students Advisory Committee

Total 35 credits

### A.1. CORE COURSES

1. Fundamentals of microbiology (2 + 1)

Discoveries in microbiology; concepts of origin of life, abiogenesis and biogenesis, spontaneous generation theory, contribution of Louis Pasteur, Robert Koch, Alexander **Flemming**, S. A. **Waksman**, and others, their early discoveries in the development of Microbiology; recent developments in microscopy; importance of microorganisms in natural processes; sterilization principles and methods; study of microorganisms, staining, principles and applications, methods of isolation and [identification](#).
cation from different sources, and environments; preservation of microbial cultures; Protists, eukaryotic and prokaryotic microorganisms, differentiation; nutrient requirement of microorganisms carbon, nitrogen and mineral metabolism; Autotrophic, heterotrophic and chemolithotrophic microorganisms; growth of microorganisms, generation time, different phases of growth curve; microbes in extreme environments; Applications of microorganisms in industry and agriculture, Immunology, serological techniques, antigen, antibody reactions, agglutination and precipitation reactions, applications of serology, microbial serotypes; principles of microbial genetics, genetics of prokaryotic and eukaryotic microorganisms, plasmid, types and their importance, genetic variability in microorganisms, mutations and recombination techniques, mutation techniques.

**Practical**

Preparation of growth media, liquid, solid and semisolid media, selective enrichment and common media for the growth of microorganisms; enumeration of microbes by pour plate, spread and drop plate methods; determination of carbon, nitrogen and mineral requirements for microbial growth; determination of generation time and growth curve for different microorganisms; staining techniques, simple, different and structural staining techniques, metabolic excretions of microorganisms and assay techniques; antigen antibody reactions, agglutination test.

**Suggested Readings**


Schlegg, H.G. 1996 General Microbiology, Cambridge university Press, New York,

2. Morphology, cytology and classification of microorganisms (2 + 1)

Existence of microorganisms in nature, bacteria, fungi, actinomycetes, protozoa, viruses; morphology of bacteria, morphological variations in bacterial cell wall and cell membrane; pili, flagella; fimbriae, capsule formation; endospore formation and structure; morphology of fungi, cell wall structure, the fungal thallus - unicellular fungi, filamentous fungi, large plectenchymatus structures septa in fungi; morphology of actinomycetes; morphology of algae, types of vegetative forms, heterocystous and non heterocystous forms, coccolithous in algae; morphology of protozoa, shapes and sizes of, protozoa; mycoplasma anatomy and architecture of viruses, bacteriophages; cytology of bacterial cell, cytoplasmic membranes, structure and transport mechanism, mesosomes, DNA, RNA constituents, ribosomes, cytoplasmic inclusions; cytology of fungi, mitochondria, golgi bodies formation, cell inclusions; cytology of protozoa, body coverings and skeletons in protozoa, locomotory organelles in protozoa, internal organelles of protozoa; microbial world, systematic position of microorganisms, general principles of classification, evolution, methods of classification, modern approaches in classification, numerical taxonomy, DNA homology, adenosine method of classification; classification of bacteria, Bergey's manual; classification of fungi, lower and higher fungi; classification of actinomycetes - outline classification of algae; protozoa, mycoplasma viruses, nature and properties; classification and nomenclature of viruses; molecular techniques in classification of microorganisms.

Practical

Examination of cell wall, Gram positive / Gram negative, cell membrane structure; endospores; flagellar structure; examination of internal structures of bacteria; fungal types, sclerotia, chlamydospores, sporangial structures, sporulation and budding in yeast; morphological differentiation of actinomycetes; examination of cell wall; observation of different morphological structures of algae; protozoa types; internal organelles examination; phages formation and observation; cultural and biochemical characters of bacterial genera in each order; fungi, systematic studies of different classes of fungi, algal types, protozoan types and DNA hybridization.

Suggested Readings


York.


3. Microbial physiology (2+ 1)

Introduction and scope of microbial physiology; nutritional diversity among microorganism, mechanisms of nutrient transport in microorganisms; physiology of microbial growth environmental influence on growth; bioenergetics; function of enzymes, co-enzymes and prosthetic groups, constitutive and adaptive enzymes- enzyme kinetics; pathways of hexose break down, Embeden Meyerhoff paraña, pathway, pentose phosphate pathway. Entner Doudroff pathway, oxidation of pyruvate, TCA cycle; utilization of reserve material, starch, glycogen and lipids; respiratory chain and electron transport, heterotrophic generation of ATP, autotrophic generation of ATP; electron transport under anaerobic conditions, denitrification, nitrate and nitrite reduction, sulphate and sulphur reductions and H2S formation; fermentation of mixed acids; methane, formation by reduction of CO3, other reductions, carbonate to acetate, fumarate to succinate- reduction of iron oxides, aerobic chemolithotrophic bacteria, inorganic hydrogen donors, oxidation of molecular hydrogen, oxidation of reduced sulphur, ferrous iron and manganous. biosynthesis of building blocks and macromolecules, amino acids and protein synthesis, nucleotides, fatty acids, phospholipids, isoprenoids, phototrophic bacteria and photosynthetic apparatus, the process of photosynthesis, oxygenic and anoxygenic photosynthesis, carbon dioxide fixation by calvin cycle; regulation of metabolism, regulation of enzyme activity and synthesis, induction and repression, mechanisms of regulation.

Practical
Growth of microorganisms in various carbon and nitrogen sources; Measurement of growth and mathematical expressions; effect of environmental factors such as pH, temperature etc. on growth; aerobic and anaerobic respiration with suitable substrates; study of bacterial photosynthesis, nitrate and nitrite reductase assay, estimation of protein assimilation use of radioactive tracers (32P 34S etc.) in metabolism

Suggested Readings


4. Microbial genetics

Discoveries in microbial genetics; early concepts of bacterial variations, adaptation, mutation and selection; the cytological basis of microbial genetics; genetic components of bacteria and fungi and segregation of genetic characters; molecular aspects of genetic components of DNA and RNA, arrangement of nucleotides, replication of DNA and in vitro synthesis, denaturation and renaturation, of nucleic acids-DNA, RNA as source of information; mutation-evidence for the occurrence of mutations in bacteria; newcombe's experiment, fluctuation test, indirect selection test etc. back mutation and mutation rates, mutagens and molecular basis of mutagenesis, Biochemical mutants-different types; genetic recombination, mechanisms of recombination, intergeneric and intrageneric recombination; transformation, transformation of pneumococcal capsular types, cellular competence and environmental conditions required for transformation-linkages; transduction, general, restricted and abortive transductions-fine structure study through transduction; conjugation, mating types, recognition of the factor, chromosome transfer, interrupted mating experiments, chromosome mapping, zygote induction; sexduction RTF and colicine factor; genetic im-
provement of industrially important microorganisms, plasmid and their characters; genetics of fungi, alternation of generation, *Neurospora crassa* and yeasts induction of mutation in bacteria, cytoplasmic inheritance and biochemical mutants; genetics of bacteriophage and phage induced mutation; genetics of viruses.

### Practical

Observation of genetic variations and inheritance in *Neurospora crassa* and yeast; induction of mutation in bacteria through physical, chemical and biological agents and studying the mutation rates; replica plateing technique and isolation of auxotrophic mutants; DNA isolation and studying the plasmid profile in bacteria; studying the transfer of specific characters by conjugation and calculation of the conjugation frequency; interrupted mating experiment and chromosome mapping in bacteria-plasmid transfer in bacteria.

### Suggested Readings

- Freifelder, P. 1987 *Microbial genetics*. Jones and Bartlett Publ., Boston, USA

### A. 2 OPTIONAL COURSES

1. **Microbial ecology** *(1+1)*

Microbial community, ecological hierarchy, inhabitants of the community, habitat and Niche; dispersal, efficiency of dispersal, active dispersal- passive dispersal- air, water, soil, biological vectors-colonization; barriers to colonization; structure and physiological adaptation;
succession, characteristics of succession climax-community; energy sources-pattern of microbial nutrition, degradation and utilization of insoluble substances, nutrient effects on distribution and activity, interspecific relationship, neutralism, commensalism, protocooperation, mutualism, parasitism, amensalism, predation, relationship of cell morphology and cytology to ecological factors, effect of microbes on animals and plants; effect of syntropism and cometabolism in microorganisms, determination of specific growth rate of microorganisms; energy flow on ecosystems, energy transformation in ecosystem, primary production, secondary production; density and adaptation of microbes in various ecosystems, fresh water, marine, sewage, atmosphere and extreme environments, ecosystem management.

Practical

Enumeration of microorganisms in soil, sewage, fresh water and marine ecosystems; effect of temperature, moisture, pH stress on microorganisms; microbial adaptations; study of microbial succession pattern in different ecosystems, microbial utilization of insoluble substances-plant residues, animal residues; pattern of growth; isolation of microbes producing antimetabolites; study of interrelationship, amensalism, antibiotics production, crowded plate technique; predation; study of interrelationships between micro and macroorganisms.

Suggested Readings


2. Soil microbiology

Discoveries in soil microbiology; distribution of microorganisms in soil, quantitative and qualitative estimation of microorganisms in soil, role of microorganisms in soil fertility; influence of soil and environmental factors on microflora, moisture, pH, temperature, organic matter, agronomic practices etc.; distribution of microorganisms, in organic manure and composts; microorganisms in soil processes, carbon cycle, organic matter decomposition, humus formation, nitrogen cycle, nitrogen fixation, symbiotic, non symbiotic, associative organisms, ammonification, nitrification, denitrification, reactions, organisms involved, factors affecting nitrogen transformation; microbial transformation of phosphorus, iron, sulphur, micronutrients in soil phosphorus solubilization by phosphobacteria and P mobilization by mycorrhizal fungi, iron toxicity and iron bacteria, sulphur toxicity and sulphur bacteria; interrelationships between plants and microorganisms, rhizosphere concept, quantitative and qualitative studies, R: S ratio rhizoplane; spermosphere; phyllosphere microorganisms; their importance in plant growth; pesticides and other agrochemicals; recalcitrant molecules; plant growth regulators and phytotoxin production by microorganisms; use of soil microorganisms for pest and disease control; effect of pesticides on soil microflora. Influence on soil microflora; microbial decomposition of chemicals applied to soil - microbial leaching of metal ores.

Practical

Enumeration of microbial population in soil; qualitative and quantitative distribution; isolation of symbiotic nitrogen fixing bacteria - non symbiotic and associative symbiotic bacteria; soil algae; nitrification; denitrification; organic matter decomposition; CO2 evolution; rhizosphere; spermosphere; phyllosphere; Frankia isolation; mycorrhizae; isolation and plant infection studies; associative and antagonistic relationships among soil microorganisms; isolation of sulphur and iron bacteria; isolation and study of phosphobacteria and phosphorus solubility.

Suggested Readings


3. **Fermentation technology**

Concept and scope of microbial fermentation technology, inoculum, screening and selection, fermentation medium, fermentation processes, dual and multiple fermentation, continuous fermentation, batch fermentation; bioreactors, types, designs and functional characteristics; scaleup of fermentation; strain improvement fermentation economics; fermentation processes, down stream processing and product recovery, production of organic solvents-ethyl alcohol, butyl alcohol, and acetone; beverages; beer and wine; amino acids, lysine and glutamic acid; vitamins and growth factors; vitamin B2 (riboflavin), vitamin B12 (cobamide), gibberellins; enzymes-amylase, cellulase, glucose and isomerase, organic acids, citric, lactic, butyric and propionic acids; antibiotics-penicillin, streptomycin, tetracyclines and microbial polysaccharides; principles of immobilisation, kinds of immobilisation techniques and their importance; sources of industrially important microorganisms in India and abroad.

**Practical**

Screening industrially useful microorganisms and their growth characteristics; preparation of inoculum and fermentation media; fermentation of alcohol, organic, acids, amino acids, enzymes and antibiotics; immobilization techniques for increasing the fermentation products; bio assay techniques for antibiotics and vitamins.

**Suggested Readings**


4. Biofertilizers

Biofertilizers; development and the concept; contribution of microorganisms to soil fertility; groups of biofertilizers, organisms that fix atmospheric nitrogen - free-living, aerobic, symbiotic, endophytic bacteria-organisms solubilising and mobilizing mineral phosphates; biochemistry and genetics of nitrogen fixation, nitrogenase, action of nitrogenase, hydrogenase, assay of nitrogen fixation; physiology of legume root nodule haemoglobin; synthesis, function, location, biochemistry and physiology of actinorhizal nodules; nitrogen assimilation; transporting of fixed nitrogen in symbiotic systems; mechanism of P solubilization by phosphobacteria and mobilization by mycorrhizal fungi; bacterial biofertilizers; Rhizobium, Bradyrhizobium, Azorhizobium, Azotobacter, Azospirillum, Acetobacter diazotrophicus - phosphobacteria and Frankia; algal fertilizer, blue green algae; Azolla. Importance; mycorrhizal biofertilizers and their importance, mycorrhizae, ectomycorrhizae, endomycorrhizae, role of mycorrhizae, principles of mass production, growth characteristics of different groups of organisms; mass multiplication techniques, fermentation media, raw materials, inoculum preparation, carrier material, types and quality, mixing of carrier, broth, population dynamics in the inoculant during storage, immobilization of cyanobacterial inoculant, principle; shelf life; quality control of biofertilizers, BIS standards of biofertilizers, of biofertilizers and its economics; field performance of biofertilizers; method of application, survival in soil; algal multiplication, methods of application etc; mycorrhizae, ectomycorrhizae inoculant, endomycorrhizae, mass production, problems and prospects.

Practical

Isolation and testing the efficiency of various biofertilizers like Rhizobium, Azotobacter, Azospirillum, Acetobacter, BGA, phosphobacteria; mass multiplication techniques of Rhizobium, Azotobacter, Azospirillum, BGA, phosphobacteria; fermentor and fermentation requirements- pH, aeration; shelf life assessment of the inoculant quality control; storage techniques; methods of application; multiplication technique for Azolla in laboratory and field scale, enumeration of Chlamydospores in soil and identification of different genera of VA Mycorrhizal fungi; multiplication techniques of mycorrhizae, field and pot culture testing of biofertilizers.

Suggested Readings


Dilworth, M.J. and A.R. Glenn, 1991. Biology and Biochemistry of Nitro-


5. **Food microbiology** (1+1)

Occurrence and role of microorganisms in food industry; primary sources of microorganisms found in food; intrinsic and extrinsic parameters of food affecting microbial growth; types of microorganisms in food like meats, poultry, seafood, vegetables and dairy products; assessing microbial load on food and food products, physical, chemical and immunological methods; microbial spoilage of different types of food; fruits, vegetable, milk, meat poultry and sea food; principles of food preservation; food preservation using chemical, irradiation, low temperature, high temperature and drying processes, aseptic packaging materials; fermentation of food and related products; fermentation of pickles, sauerkraut, bread, idly and curd; fermentation of vinegar and lactic acid Microbiology of processed canned fords; microorganisms as food; single cell protein; food sanitation, indicator organism, Coliform bacteria, foodborne diseases and food poisoning; botulism, salmonellosis-gastroenteritis-food pathogens, *Clostridium perfringens*, *Vibrio haemolyticus*, *Campylobacte jejuni*; food processing plant sanitation, microbiological
standards and guidelines, quality control and food laws.

Practical

Examination of microorganisms on normal and spoiled fruits and vegetables, cereal products, sugar products, dried fruits and vegetables; use of food preservatives viz. chemicals, irradiation, low and high temperature on the control of foodborne microorganisms; microbial spoilage of canned and bottled food, meat and fish; diagnosis of spoilage of various food; microbiological survey in utensils and processing plants; fermentation of lactic acid and vinegar; assessing the load of Coliform bacteria and Salmonella as indicator organisms.

Suggested Readings


6. Microbial management of organic wastes

Organic wastes in the biosphere, tropical ecosystem, organic wastes in temperate and forest ecosystems; composition, source and quantum of wastes; qualitative nature of wastes; decomposition of the organic materials, processes of decomposition, aerobic and anaerobic degradation, mechanism of degradation, factors influencing degradation - moisture, temperature etc.; degradation of simple carbon compounds, monosaccharides, polysaccharides, complex substances, organisms involved; enzymes, byproducts; microbiology of anaerobic digestion, acetogenic and methanogenic microbes, biochemistry of conversion of cellulose to methane, farm and urban wastes, decomposition, methods and mechanism of composting, enriched compost; sewage, solid and liquid wastes, quality and quantity, sewage treatments, oxidation ponds, activated sludge etc., trickling filters, recycling of sewage water, organisms, pathogens, decomposers involved; agroindustrial wastes, wastes from sago factory, paper factory, sugar factory, distillery and tannery; nature and composition of the wastes; microbial conversion and useful products, substrates for microbial biomass and mushroom production; microbial deodorization and decoloration of effluents - organisms involved in degradation; microbial degradation of pesticides.

Practical
Quantitative and qualitative enumeration of microorganisms in organic wastes. Degradation of cellulose and other carbon compounds; CO2 evolution; methane generation, methanogenesis with different farm wastes; isolation and study of methanogens; succession of microorganisms in composting; microbial load in sewage, BOD and COD determination; sewage and effluent treatment; visit to sewage disposal plant; coir pith degradation; degradation of industrial wastes; use of wastes for SCP production.

**Suggested Readings**


Roberts, M. 1996. Environmental Microbiology. John Willey & Sons, USA

7. **Microbial control of crop pests and diseases**

Microflora of healthy and diseased insects; relationship between microorganisms and insects; parasitism and symbiosis, symptomology and diagnosis of microbial diseases of insects; isolation and identification of common insect pathogens; bacterial pathogens of insects; spore forming and nonspore forming bacteria; occurrence and conditions for spread of bacterial pathogens; mode of action, endo and ecto-toxins production by *Bacillus thuringiensis*, *B. popilliae*, mode of action of the toxins in insects; specificity, practical applications; genetic control of toxin production; fungal pathogens of insects; isolation and identification of common fungal pathogens *Beauveria*, *Metarrhizium*, *Cephalosporium*, *Entomophthora* etc., occurrence and conditions for the spread; important fungal diseases of harmful and beneficial insects, mode of entry and action, insect viruses; nuclear polyhedral viruses, cytoplasmic viruses etc., occurrence, spread, entry and mode of action on insects; other insect pathogens—protozoa, rickettsiae, PPLO and nematodes; microbial pathogens of plant roots viz. *Rhizoctonia solani*, *Phomopsis sclerooides*, *Sclerotium Macrophomina Phytophthora* and *Fusarium* shoots viz. *Venturia inaequalis*, *Alternaria alternata*, *Erwinia amylovora* and *Cerotostictis parasiticus* and their control by competition and antagonism; importance of *Trichoderma viride*; *T.harzianum*; *Streptomyces*, rhizobacteria, mycorrhiza and *Thiobacillus* the control of plant root pathogens; control of aerial pathogens, prophylaxis—preinoculation, and immunization with avirulent pathogens; role of microorganisms in protecting the wounds of trees; techniques of application of microorganisms for control of microbial diseases; seed treatment, aerial spray and soil.
treatment; Microbial insecticides; advantages of microbial insecticides, limitations-Mass production techniques; fermentation, formulation of insecticides, carrier materials quality control etc; compatibility of microbial and chemical insecticides; suitable insecticides for major pests; field application of microbial insecticides and its perpetuation.

Practical

Isolation and identification of the external microflora of healthy and infected; insects study of internal gut microflora of insects; study of symbiotic microflora of ants and termites; symptoms and diagnosis of diseases of insect; microbiological examination of diseased insects and isolation of the insect pathogens; assessing the lethal dose of the pathogen; demonstration of Koch's postulates; multiplication techniques of Nuclear polyhedral viruses; mass multiplication of insect pathogen; fermentation techniques; fermentation of microbial insecticides; microbial Control of root diseases and aerial pathogens; mass production and application methods.

Suggested Readings


Jayaraj, S. 1985. Microbial control and pest management

2. BIOCHEMISTRY

A. MAJOR

A.1. CORE COURSES 11 CREDITS

1. Basic biochemistry 3 + 1
2. Techniques in biochemistry 2 + 2
3. Enzymology 3 + 0

Seminar 0+1 credit

A.2. OPTIONAL COURSES 8 CREDITS

1. Intermediary metabolism 3 + 0
2. Plant biochemistry 3 + 0
3. Biochemistry of food grains, fruits and vegetables 2 + 1
4. Special biochemistry course (region/crop specific) 2 + 1
5. Inorganic nitrogen metabolism 2 + 1
6. Biomembranes 2 + 0
7. Fundamentals of molecular biology 3+ 2
8. Biochemistry of biotic and abiotic stresses 3+ 0
9. Immunoochemistry 2 + 0
10. Special topics in biochemistry 1 + 0
11. Research methodology 0 + 1

B. SUPPORTIVE COURSES 15 CREDITS

To be decided by the Students Advisory Committee Total 35 credits

A.1 CORE COURSES

1. Basic biochemistry (3+1)

Scope and importance of biochemistry in agriculture; fundamental principles governing life; structure of water; acid base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waal forces; general introduction to physical techniques for determination of structure of biopolymers; fundamentals of thermodynamics applicable to biological processes; classification, structures and functions of amino acids, proteins, carbohydrates, lipids and nucleic acids; structure and biological function of vitamins; enzymes; classification and mechanism
of action - regulation, factors affecting enzyme action, concept of oxidation-reduction in biological systems; bioenergetics, biomembranes and oxidative phosphorylation; metabolism of fats, proteins, and carbohydrates; photosynthesis and respiration; DNA replication, transcription and translation, recombinant DNA technology.

**Practical**

Preparation of buffers, nitrogen estimation by different methods, separation of amino acids by TLC, Separation of proteins on PAGE, enzyme assay, estimation of reducing and non-reducing sugars, estimation of oil, iodine value, saponification value and acid value, fatty acid composition by GLC, isolation and quantification of nucleic acids, estimation of ascorbic acid, estimation of riboflavin and thiamine.

**Suggested Readings**


2. **Techniques in biochemistry**

pH and buffers; preparation and purification of cell organelles; spectrophotometry (UV, visible, infrared) and spectrofluorometry; ultracentrifugation; chromatographic techniques-basics, ion exchange, gel filtration and affinity chromatography, GLC and HPLC; electrophoretic techniques for protein and nucleic acid separation-PAGE,
SDS-PAGE, isoelectric focussing; ELISA use of radioisotopes in biochemistry including autoradiography and safety aspects; mass spectroscopy, nuclear magnetic resonance; X-ray crystallography; neutron scattering technique.

Practical

pH and preparation of buffers, soluble protein estimation, fractionation of cell organelles, estimation of sugars by colorimetric methods, extraction of lipids and their separation on TLC, estimation of iodine value and saponification value, separation of amino acids by TLC, analysis of N-terminal amino acids, separation of proteins and isozyme analysis by PAGE, molecular weight determination by SDS-PAGE, enzyme purification (Amylase/Peroxidase/Lysozyme) - acetone powder, ammonium sulfate fractionation, ion exchange/gel chromatography, enzyme kinetics, GLC, HPLC, DNA isolation and agarose gel electrophoresis, polysome isolation by sucrose density gradient centrifugation, fluorimetric estimation of vitamins, liquid scintillation counting.

Suggested Readings


3. **Enzymology**

Introduction and historical perspective; classification and nomenclature; isolation and purification of enzymes; cofactors - structures and biological functions; theory of enzymatic catalysis, specificity, concept of active site and enzyme substrate complex, active site mapping, covalent and acid base catalysis, factors associated with catalytic efficiency, proximity, orientation, distortion and strain, induced fit hypothesis; kinetics, chemical kinetics a brief review, enzymatic kinetics; effect of substrate concentration, derivation of Michaelis-Menten equation, Ks, Km, Vmax, and Kcat and their significance; methods to determine Km and Vmax with their merits and demerits; Briggs- Haldane steady state approach, King-Altman patterns, computer simulation of Michaelis-Menten equation; effect of different factors affecting enzyme activities; transition state theory; Arrhenius equation; determination of energy of activation; optimum temperature and thermal stability of enzyme; inhibition of enzyme catalyzed reaction, irreversible and reversible, competitive, noncompetitive, mixed type, bisubstrate reaction kinetics; random, ordered and Ping-Pong mechanisms; allosteric enzymes; basic concept; significance, positive and negative effectors, heterotropic and homotropic effects; determination of binding sites, Hill plot, Scatchard plot, sequential and symmetry models; isozymes, multienzyme complexes and systems, bifunctional enzymes. Immobilized enzymes; relative practical and economic advantages for industrial uses; effect of partition on kinetics and performance with particular emphasis on charge and hydrophobicity, immobilized enzyme systems; ribozymes.

**Suggested Readings**


Wilson, K. and Walker, J. (Eds.). 2000. Principles and Techniques of
A. 2 OPTIONAL COURSES

1. Intermediary metabolism

The living cell: a unique chemical system; experimental approaches to study metabolism; transport mechanisms, thermodynamics, kinetics and mechanism. active and passive transport; signal transduction, carbohydrate metabolism, glycolysis, Krebs cycle, HMP pathway, glyoxylate pathway, glycogen synthesis, and its regulation, bioenergetics, electron transport, oxidative phosphorylation and its regulation; lipid metabolism and its regulation; amino acid metabolism; general reactions, degradation and biosynthesis, sulphur metabolism; metabolism of nucleic acids; degradation and biosynthesis of purines and pyrimidines; regulation and integration of metabolic pathways.

Suggested Readings


2. Plant biochemistry

Plant cell organelles and their separation; structure and function of cell organelles. photosynthetic pigments in relation to their functions; photosynthesis, generation of NADPH and ATP; C3, C4 and CAM pathway and their regulation; photorespiration, sucrose-starch interconversions, biosynthesis of structural carbohydrates, proteins and lipids. Biochemistry of nitrogen fixation and nitrate assimilation; sulphate reduction
and incorporation of sulphur into amino acids; biochemistry of seed germination and development; biochemistry of fruit ripening, phytohormones and their mode of action; signal transduction; biochemistry and significance of secondary metabolites - cyanogenic glycosides, glucosinolates, phenolic compounds, terpenoids, alkaloids; plant defence system.

Suggested Readings


3. Biochemistry of food grains, fruits and vegetables (2+1)

Fundamentals of human nutrition, concept of balanced diet; biochemical composition and food value of various food grains (including cereals, pulses, oil seeds), fruits and vegetables, biochemistry of food spoilage, role of lipase and lipoxygenase; antinutritional factors, biochemical aspects of post-harvest technology such as storage and preservation; fundamentals of food processing; biochemical basis of nutritional quality-improvement of food grains, vegetables and fruits; factors affecting nutritive value of food grains, fruits and vegetables.

Practical

Suggested Readings


4. Special biochemistry course (2+1)

This course would be region/crop-specific, e.g., biochemistry of tea, biochemistry of tuber crops, biochemistry of plantation crops. (Course content is to be decided by the concerned University/Institute).

5. Inorganic nitrogen metabolism (2+1)

Biochemistry of nitrogen cycle; biological nitrogen fixation; structure, function and regulation of nitrogenase; structure, function and regulation of nif genes in Klebsiella pneumoniae; biochemical basis of legume-Rhizobium symbiosis; genes involved in symbiosis; different types of hydrogenases and role of uptake hydrogenase in N2-fixation; chemoautotrophy in rhizobia; biochemistry of ferredoxin and other non-heme iron proteins; biochemistry of nitrate assimilation and mechanism of its regulation; GS/GOGAT and GDH pathway; ureides and amides as nitrogen transport compounds; biochemistry of denitrification process and phosphorylation in denitrifying bacteria; nitrification process and path of carbon assimilation in nitrifying bacteria.

Practical


**Suggested Readings**


6. **Biomembranes**

Concept of biomembranes and their classification based on cellular organelles; physico-chemical properties of different biological and artificial membranes, cell surface receptors and antigen, membrane biogenesis and differentiation; membrane components - lipids, their distribution and organisation; proteins, intrinsic and extrinsic, their arrangement; carbohydrates in membranes and their function, various membrane movements; transport across membrane and energy transduction, role of membrane in cellular metabolism, cell recognition and cell-to-cell interaction; signal transduction, recent trends in membrane research.

**Suggested Readings**


Smallwood, M., Knox, J.P. and Bowls, B.J. 1996. Membranes: Special-
ised Functions in Plants, Bros Scientific Publishers.


7 Fundamentals of molecular biology (3+2)

Historical development of molecular biology; nucleic acids as genetic material, chemistry and structure of DNA and RNA; biosynthesis of purine and pyrimidine nucleotides and their regulation; genome organisation in prokaryotes and eukaryotes; chromatin structure and function. DNA replication, DNA polymerases, topoisomerases, DNA ligase; reverse transcriptase; repetitive and non-repetitive DNA, satellite DNA; transcription process, RNA editing, RNA processing; molecular mechanism of regulation of lac operon, attenuation of trp operon; RNA replicase; ribosomes, structure and function, organisation of ribosomal proteins and RNA genes, genetic code; aminocytRNA synthases; inhibitors of replication, transcription and translation; translation and post-translational modifications; nucleases and restriction enzymes, DNA sequencing, recombinant DNA technology, vectors, isolation of genes, recombinant vector, selection of recombinants, PCR; general features of replication, transcription, site directed mutagenesis and translation in eukaryotes.

Practical

Estimation of DNA and RNA, isolation of plasmids, Isolation of genomic DNA from crop plants, isolation of total RNA and poly (A)+ RNA, Agarose gel electrophoresis of DNA and RNA, restriction analysis of DNA, Radiolabelling of DNA (probe making), Southern blotting and hybridization, Isolation of ribosomes, rRNA and r-proteins, In vitro translation, PAGE of in vitro translated products, DNA sequencing.

Suggested Readings


Blackburn, G.M. and Gait, M.J. 1996. Nucleic Acids in Chemistry and
8. Biochemistry of biotic and abiotic stresses (3+0)

Plant-pathogen interaction and disease development; molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants; plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance; plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids, pathogen-derived resistance; biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants, interaction between biotic and abiotic stresses; stress adaptation; molecular strategies for imparting tolerance against biotic and abiotic stresses

Suggested Readings


9. Immunochemistry

History and scope of immunology; components of immune system. Immunoglobulins chemistry, structure and functions; antigens, haptens and complement system; biochemistry and interactions of antigens, antibody and lymphocytes; molecular organisation of immunoglobulins and classes of antibodies, antibody diversity; immuno-regulation; vaccines; monoclonal antibodies and their uses; current immunological techniques - ELISA, radioimmunoassay.

Suggested Readings


10. Special topics in biochemistry

Presentation/Discussion on current topics in biochemistry.
11. Research methodology

Introduction - seminar paper preparation and presentation; how to write dissertation? guidelines for review of literature, materials and methods, results and discussion, presentation, references, Writing research project, setting up of a biochemistry laboratory, infrastructural and working facilities, implementation, project cost, Budget; Bioinformatics, online and off-line information retrieval, browsing biological databases through internet; molecular modelling using IRL software, protein-folding studies and plasmid construction using software; use of software for deletion and insertion of DNA fragments in standard plasmids; DNA sequencing, downloading sequence homology from internet, gene bank, EMBL sources and comparing the sequences; Dendrogram construction using software using NTSys; mapmarker and UPGMA based analyses; RFLP/RAPD/AFLP data handling; use of software for graphing, slide making, poster preparation; scanning gels, photography, X-ray photography and autoradiography perspectives.

Suggested Readings

### A. MAJOR

#### A.1. CORE COURSES

<table>
<thead>
<tr>
<th>Course Description</th>
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<tr>
<td>Molecular genetics</td>
<td>2 + 1</td>
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<tr>
<td>Molecular biology</td>
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<tr>
<td>Cell biology</td>
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<tr>
<td>Genetic engineering - principles &amp; methods</td>
<td>3 + 1</td>
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<td><strong>Seminar</strong></td>
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#### A.2. OPTIONAL COURSES

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<th>Course Description</th>
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<tr>
<td>Techniques in molecular biology</td>
<td>0 + 3</td>
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<tr>
<td>Molecular genetics of plasmid and bacteriophage</td>
<td>2 + 0</td>
</tr>
<tr>
<td>Plant tissue culture</td>
<td>2 + 1</td>
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<tr>
<td>Plant molecular biology</td>
<td>2 + 0</td>
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<tr>
<td>Gene regulation</td>
<td>2 + 0</td>
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<tr>
<td>Enzymology</td>
<td>2 + 1</td>
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<tr>
<td>Introduction to industrial biotechnology</td>
<td>2 + 0</td>
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<tr>
<td>Plant genetic engineering</td>
<td>2 + 0</td>
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<tr>
<td>Principles of immunology</td>
<td>1 + 1</td>
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<tr>
<td>Biotechnology and society</td>
<td>1 + 1</td>
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<tr>
<td>Biomolecule prospecting</td>
<td>2 + 0</td>
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<td>Molecular biology of plant viruses</td>
<td>2 + 0</td>
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<tr>
<td>Protein engineering</td>
<td>2 + 0</td>
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### B. SUPPORTIVE COURSES

To be decided by the Students Advisory committee  
Total 35 credits

#### A.1 CORE COURSES

1. Molecular genetics  

Model genetic systems- lambda, *E.coli*, *Neurospora*, yeast, *Drosophila*, *Arabidopsis* and maize; principles of inheritance, qualitative and quantitative traits, DNA as genetic material; sources of genetic variation, molecular basis of genetic variation, induced mutagenesis, physical
chemical and biological site directed mutagenesis, gene transfer in prokaryotes, conjugation, transformation and transduction, fine structure analysis of gene, complementation and test of allelism, changing concept of gene, pro and eukaryotic genomes, genome complexity, repetitive vs unique DNA sequences, chromatin and chromosome structures, DNA and chromosome replication, artificial chromosomes, genetic recombination and repair; chromosome mapping, genetic, physical and molecular maps, molecular mapping and tagging of genes, marker assisted selection; structural organizational of genes in pro & eukaryotes, operon concept, gene expression and regulation, positive and negative controls, genetics of antibody diversity, molecular genetics of cell division and aging, DNA fingerprinting and biodiversity, functional genomics.

Practical

Bacterial and phage tine estimation; growth kinetic studies; characterization on bacterial strains for antibiotic and drug resistance; induced mutagenesis; chemical, physical, biological and site directed; gene transfer methods and gene mapping in bacteria; complementation test; analysis of gene regulation employing E. coli mutants; construction of restriction maps; construction of molecular maps, gene mapping and QTL analysis; DNA fingerprinting, estimation of genetic diversity and phylogenetic analysis.

Suggested Readings

Old, 1997, Principles of gene manipulations, Blackwell Publication, UK
Paterson, A.H. (1996), Genome mapping in plants, Academic Press, USA

2. Molecular biology

Historical development of molecular biology, chemistry & structure of DNA and RNA; biosynthesis of purine and pyrimidine nucleotides and their regulation, genome organization in prokaryotes and eukaryotes, chloroplast and mitochondrial DNA, molecular structure and function, chromatin structure and function, DNA replication, repetitive and non repetitive DNA, satellite DNA; transcription processes, RNA editing & RNA processing, ribosomes, structure of function, organization of ribosomal RNA genes, genetic code, aminoacyl tRNA synthetases; translation and post translational modifications, nucleases and restriction enzymes, DNA sequencing.
Practical

Preparations of buffers, solutions; isolation of genomic DNA from crop plants; isolation of total RNA & poly (A)+ RNA; agarose gel electrophoresis of DNA and RNA; determination of base composition of DNA; measurement of reassociation kinetics and Tm of genomic DNA; restriction analysis of genomic DNA; radiolabelling of DNA (probe making); Southern blotting & hybridization; isolation of ribosomes, rRNA & r-proteins; in vitro translation and PAGE of in vitro translated products; DNA sequencing.

Suggested Readings


Freifelder, D. 1990 (2nd edition) Molecular Biology, Springer Verlag


Christopher Wills. The wisdom of the genes. Oxford University Press


3. Cell biology (1 + 1)

Evolution and cell theory, general structure and constituents of plant cells; similarities and distinctions between plant and animal cells; cell wall, cell membrane, cell surface related functions; endoplasmic reticulum, nuclear structure, synthesis and function; cyto - skeletal elements; structure and function of major organelles; chromosome, chloroplast, mitochondria, ribosomes in relation to cell growth and division; specialized cells in various tissues; regulation of cell cycle and cell division, regulation of cellular function by growth factors and hormones.

Practical

Fractionation of tissues and cells; isolation of cellular organelles and macromolecules; chromatography, ultracentrifugation techniques,
lectrophoresis; microscop preparations, specimen and staining procedure.

Suggested Readings


4. Genetic engineering - principles and methods (3 + 1)

Recombinant DNA technology, characteristic of vectors derived from bacterial plasmids and phages and plant and animal viruses; restriction enzymes; DNA cloning strategies, preparation and screening of genomic and cDNA libraries; Identification and isolation of structural genes and regulatory elements, changing genes; site-directed mutagenesis; transfer of cloned DNA and expression of cloned genes into foreign cells; bacteria plants & animal, cells; problem in gene transfer & expression; potential application of genetic engineering in agriculture, medicine and industry; genetic engineering of secondary metabolites, analysis of bio-safety aspects of gene manipulation; antisense RNA; ribozymes; PCR, DNA sequencing; the impact of recombinant DNA technology; biosafety aspects & patents.

Practical

Isolation of plasmid DNA and restriction; isolation of plant DNA and restriction; isolation of virus DNA and restriction; agarose gel electrophoresis of restricted DNA samples; cloning in phage and plasmid based vectors; transduction of E. coli and in vitro packaging; preparation of radio labelled DNA probe; Southern blotting and hybridization; isolation and identification of positive clones; cloning and sub cloning; DNA sequencing by Sanger's dideoxy method.
Suggested Readings


A. 2 OPTIONAL COURSES

1. Techniques in molecular biology (0+3)

Extraction of proteins and nucleic acids, their quantification, electrophoresis of proteins, molecular weight determination, Western blot analysis, extraction and estimation of DNA, total RNA and mRNA isolation and purification of plasmid DNA, restriction, agarose gel electrophoresis, elution of fragments from gels, Southern transfer and hybridization, autoradiography, competent cell preparation, RFLP & RAPD analysis, PCR & DNA sequencing, ELISA & RIA.

Practical

Extraction of proteins and quantification; polyacrylamide gel electrophoresis of proteins; isolation of plant DNA, phage DNA and plasmid DNA; isolation and purification of total RNA and mRNA; restriction analysis of DNA; radiolabelling of DNA; Southern transfer and Southern hybridization and autoradiography; PCR and DDRT – PCR; RAPD analysis; DNA sequencing; deletion mapping; DNAase I foot printing; gel retardation assay; ELISA.

Suggested Readings


2. Molecular genetic of plasmids and bacteriophage (2+0)

Plasmids and episomes, their general structure and variation in size; determinants of incompatibility and fertility inhibition; conjugate mobilization genes and genes for surface exclusion, integration, excision and amplification; plasmid transformation requirements; structure, organization and functioning of insertion and transformation elements; plasmids as vectors; plasmid carrying genes of economic importance; types of prokaryotic viruses, genome organization and replication of single stranded RNA and DNA and double stranded DNA phages of bacteria, genetic control of gene expression by self and host coded products, phage host interactions, molecular genetics of lysogeny, immunity and phage variation transduction, secondary functions specified by phages.

Suggested Readings


3. Plant tissue culture (2 + 1)

History and scope, totipotency and cell theory; growth and differentiation of plants; growth regulation of morphogenesis, somatic embryogenesis; application of tissue culture for plant improvement, micropropagation, embryo rescue, anther culture, germplasm conservation, production of secondary metabolites, somaclonal variation, cel-
lular mutagenesis, protoplast culture, somatic cell genetics, alien gene transfer; cryopreservation.

**Practical**

Preparation of nutrient media; handling and standardization of plant material; isolation, inoculation and subculturing; estimation of callus cells suspension culture; protoplast isolation and culture; plant segmentation; micropropagation; selection of cell lines for various stress conditions; gene transfer experiments, Direct and indirect methods; transformation and regeneration of plant protoplasts.

**Suggested Readings**


Fundamental Methods, Narosa Publication.


4. **Plant molecular biology** (2+0)

Plants as genetic system; general organization of nuclear, mitochondria and chloroplast genomes; tissue specific expression of genes; structure, organization and regulation of nuclear genes concerning storage proteins, sugar and starch synthesis; genes responding to hormones, phytochrome, abiotic and biotic stresses; plant - microbe interaction; genes involved in photosynthesis and nitrogen fixation; genetic interactions between nucleus, chloroplast and mitochondria; mitochondrial control of fertility; selectable markers in plants and their uses; single transduction, molecular farming.

**Suggested Readings**

Old, 1997, Principles of gene manipulations, Blackwell Publication, UK

Paterson, A.H. (1996), Genome mapping in plants, Academic Press, USA


5. **Gene regulation** (2+0)

Concept of gene and genome, general control of DNA, RNA and protein
synthesis; gene regulation in prokaryotes; gene clustering and operon concept; mechanism of positive and negative control of gene expression; translational and transcriptional control of regulatory mechanism of gene expression in eukaryotes; role of post - transcription and post - translational events in gene regulation; Isolation of repressor and characterization of operator.

Suggested Readings


6. Enzymology

Enzyme nomenclature and classification, assay, isolation, purification and characterization; structure conformation, specificity, mechanism of action, transient and steady state kinetics, active site mapping, regulation of enzyme activity, multi enzyme complexes, immobilized enzymes, application of enzyme in chemical and food industry, clinical applications of enzymes.

Practical

Isolation of soluble proteins and their characterization; isolation and purification of enzymes; determination of activity and specific activity of an enzyme; determination of Km and V max; enzyme kinetics; enzyme inhibitors.

Suggested Readings


7. Introduction to industrial biotechnology

Concept and scope of microbial fermentation technology, inoculum,
screening and selection fermentation medium, fermentation process - bioreactor types design, fermentation economic, fermentation of food and related products, production of organic solvents - beverages - amino acids, single cell protein, vitamins and growth factors antibiotics and enzymes, genetic engineering and production of human proteins through microbes, commercial application of genetically engineered microbes, biosensor, industrial production of commercially important biofertilizers and biopesticides, microbial degradation of waste products; biomining and metal extraction, phytoremediation.

Suggested Readings


8. Plant genetic engineering

Methods of plant breeding in relation to the reproductive system; comparison of strategies of crop improvement, isolation and characterization of plant genes and promoters, construction and screening of cosmid based library using homologous and heterologous probes; construction of vectors for gene transfer, methods of gene transfer, study of transgene integration and expressions, copy number variation, transgene inheritance and stability, plant genetic engineering for stress tolerance, male sterility and herbicide tolerance and modification of carbohydrate, protein and oil; post - harvest quality, production of bioplastics, plastibodies and vaccine; processing of genetically engineered variability for evolving superior genotypes; transgenic plants and environmental issues.

Suggested Readings


9. **Principles of immunology**

History and scope of immunology, antigens, adjuvants immune system, organs, tissues and cells, immunoglobulins, chemistry and structure and their biological functions, cellular interaction in the immune response antigen recognition - T cell receptors, cell mediates immune repossess, immuno-regulation, immunological tolerance, immunological application in plant science, monoclonal antibody in plant disease diagnosis.

**Practical**

Handling, inoculation and bleeding of laboratory animals; preparation of antigen; antibody and antigen reaction; preparation of lymphocyte from blood; immuno electrophoresis radial transdiffusion; quantitation of immunoglobulins by zinc sulphate.

**Suggested Readings**


10. **Biotechnology and society**

Nature, diversity and organization of life on plant earth; various mechanisms of generation of genetic diversity and their evolutionary implications; synthesis and transplantation; socio-economic aspects of use of cloned genes in medicine, agriculture, industry and ecology, guidelines for research involving genetically modified organisms (GMO), biodiversity, gene banks, intellectual property rights (IPR), GATT, TRIPS, farmers rights, ethical and socio-economic issues.
Suggested Readings


11. Biomolecule prospecting (2+0)

Important metabolic pathways, secondary metabolites, isolation and purification, characterization of compounds of agricultural and pharmaceutical importance from microbes and plants, prospecting genes for these compounds from the germplasm, strategies for large scale production of important biomolecules, application potentials and scope of commercialization.

Suggested Readings


12. Molecular biology of plant viruses (2+0)

Nomenclature and classification of viruses; variation, mutation and origin of viruses; virus and methods of their identification; use of monoclonal antibodies in identification of viruses and their strains; composition and structure of viruses; Molecular biology of viral genome replication, transcription, protein synthesis and maturation; viral genome organization and functions of viral proteins; ultrastructural changes in the host; cross protection; production of genetically engineered resistance plants; genetics of viruses ; viruses as vectors of information transfer; cryptic viruses; sub - viral pathogens.

Suggested Reading

Vidhyasekaran,P. 1997. Fundal pathogenesis in plants and crops: Mo-
lecular Biology and host defense mechanism. Marcel Dekker, New York.


Day, P.H. 1986. Biotechnology, crop improvement and protection, BSPC, UK


13. **Protein Engineering** *(2+0)*

Protein structure and functional relationship, sequencing synthesis, structural determination, concept in active site and catalytic mechanism, modification in primary structure, site-directed mutagenesis, post-transnational modifications, macro-modifications of proteins - metabolic engineering and gene fusion, fusion protein stability and deflectability, alternation of biological properties ribozyme technology, immobilized enzyme technology.

**Suggested Readings**


4. CROP PHYSIOLOGY

A. MAJOR

A. 1. CORE COURSES 12 CREDITS

1. Principles of plant physiology-I. cell organelles, water relations and mineral nutrition 2 +1
2. Principles of plant physiology-II. metabolic processes and growth regulation 2 + 1
3. Abiotic stress responses in plants 2 +1
4. Morphogenesis, tissue culture and plant transformation 2 +1

Seminar 0 + 1 credits

A.2 OPTIONAL COURSES 8 CREDITS

1. Crop physiology 1+0
2. Plant growth regulators and plant development 2+1
3. Physiological, molecular and ecological aspects of photosynthesis and productivity 2+1
4. Mineral nutrition; physiological and molecular aspects 2+1
5. Seed physiology 1+1
6. Physiological aspects of crops - I 2+0
7. Physiological aspects of crops - II 2+0
8. Climate variability, climate change and its impact on growth and productivity 2+0
9. Herbicide physiology 1+1
10. Physiology of flowering and reproduction 2+ 0
11. Physiology of horticultural and plantation crop species 2+ 0
12. Post harvest physiology 1+1
13. Experimental techniques in plant physiology 0+2

B. SUPPORTIVE COURSES 14 CREDITS

To be decided by the Students Advisory Ccrop species Total 35 credits
A. 1 CORE COURSES

1. Principles of plant physiology-I. cell organelles, water relations and mineral nutrition (2+1)

Cell organelles and their physiological functions; structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions; water and its role in plants; properties and functions of water in the cell water relations, cell water terminology, water potential of plant cells; mechanism of water uptake by roots, transport in roots, movement of water in plants, water loss from plants, energy balance, solar energy input, energy dissipation at crop canopy level, evapotranspiration; transpiration, driving force for transpiration, plant factors influencing transpiration rate, stomata, structure function, mechanism of stomatal movement, antitranspirants; physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels; indices for assessment of drought resistance; the role of mineral nutrients in plant metabolism; essential elements, classification based on function of elements in plants; uptake of mineral elements in plants, mechanisms of uptake, translocation of minerals in plants; physiological and metabolic functions of mineral elements; critical levels, deficiency symptoms, nutrient deficiency and toxicity; Foliar nutrition.

Practical

Measurement of soil water status; theory and principle of pressure plate apparatus, neutron probe; measurement of plant water status; relative water content, water saturation deficits Chardakov’s test; theory and principle of pressure bomb, hydraulic jack, psychrometer and osometer; measurement of transpiration rate; measurement of vapour pressure deficits, theory and principle of porometry, diffusion prometer and steady state porometer, stomatal physiology, influence of ABA on stomatal closing; mineral nutrients; demonstration of energy requirement for ion uptake; deficiency symptoms of nutrients.

Suggested Readings


Taiz, L. and Zeiger, E. (1998); Plant physiology, 2nd edition Sinauer association, INC Publishers

2. Principles of plant physiology-II. metabolic processes and growth regulation (2+1)

Photosynthesis, translocation and the respiration as key processes regulating carbon metabolism and plant growth; photosynthesis its importance in bioproductivity; photochemical process, chloroplast its structure, photochemical reactions, CO2 reduction in calvin cycle, supplementary pathway of C fixation in C4 and CAM plants and its significance; photorespiration and its relevance; photosynthesis as a diffusive process, effect of environmental factors on photosynthetic rates; synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall); translocation of photosynthates and its importance in sink growth; mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance; nitrogen metabolism; inorganic nitrogen species (N2, NO3, NH3) and their reduction to amino acids, protein synthesis and nucleic acids; lipid metabolism, storage, protective and structural lipids, biosynthesis of fatty acids, diacyl and triacyl glycerol, fatty acids of storage lipids; secondary metabolites and their significance in plant defence mechanism; growth and differentiation; hormonal concept of growth and differentiation, plant growth hormones (auxins, gibberellins, cytokinins, ABA, ethylene etc.); biosynthesis of growth hormones, their metabolism and their physiological role synthetic growth regulators, growth retardants, apical dominance, senescence, fruit growth, abscission; photo morphogenesis; photo receptors, phytochrome, cryptochrome, physiology of flowering, photoperiodism and vernalisation.

Practical

Radiant energy measurements, separation and quantification of chlorophylls, \(O_2\) evolution during photosynthesis; measurement of gas exchange parameters, conductances, photosynthetic rate, photorespiration,
respiration rates, estimation of reducing sugars, starch; estimation of NO3, free amino acids in the xylem exudates, quantification of soluble proteins, bioassays for different growth hormones, auxins, gibberellins, cytokinins, ABA and ethylene, demonstration of photoperiodic response of plants in terms of flowering.

Suggested Readings


3. Abiotic stress responses in plants

Response of plants to abiotic stresses; abiotic stresses affecting plant productivity; basic principles of a crop improvement programme under stress, interactions between biotic and abiotic stresses; drought, characteristic features, water potential in the soil, plant air continuum; development of water deficits, energy balance concept, transpiration and it's regulation, stomatal functions / VPD; physiological processes affected by drought; drought resistance mechanisms; escape dehydration postponement (drought avoidance), dehydration tolerance, and characteristics of resurrection plants; osmotic adjustment osmoprotectants, stress proteins; water use efficiency as a drought resistance trait; molecular responses to water deficit; stress perception, expression of regulatory and functional genes and significance of gene products; stress and hormones, ABA as a signalling molecule, cytokinin as a negative signal; oxidative stress; reactive oxygen species (ROS); role of scavenging systems (SOD, Catalase etc); high temperature stress; tolerance mechanisms; role of membrane lipids in high temperance tolerance; functions of HSP's; chilling stress; effects on physiological processes; crucial role of membrane lipids, salinity; species variation in salt tolerance; salinity effects at ; cellular and whole plant level, tolerance mechanisms; salt tolerance in- glycophytes and halophytes; breeding for salt resistance; heavy metal stress; aluminium and cadmium toxicity in acid soils; role of phytochelatins (heavy metal binding proteins).
Practical

Measurement of water status of plants, determination of osmotic potential by vapour pressure and freezing point depression; determination of soil water potential and content by psychrometry and other systems; stress imposition and quantification; stress, stomatal conductance; canopy temperature as a reflection of transpiration and root activity; water use efficiency, determination at whole plant and single leaf level; root-shoot signals, ABA and cytokinin effect on stomatal behaviour; heat tolerance and membrane integrity; sullivan's heat tolerance test, chilling tolerance, galactolipase and free fatty acid levels as biochemical markers for chilling damage; cold induced inactivation of O2 evolution of chloroplasts, as a screening technique for chilling tolerance.

Suggested Readings


Smith, J. A. C. and Griffith, S. H., (1993); water deficits, plant response from cell to community, BIOS scientific, Oxford.


4. Morphogenesis, tissue culture and plant transformation (2+1)

Morphogenesis; the cellular basis of growth and morphogenesis; anatomical and ultrastructural aspects of growth; polarity, in tip growing
cells and diffusive growing cells, control of plane of cell division and
differentiation in selected cell types; photoreceptors, phytochromes, dif-
ferent forms, physiological effects and gene regulation; introductory his-
tory, morphogenesis and cellular totipotency, physiology and biochem-
istry of differentiation, laboratory organisation (aseptic techniques),
organ, tissue and cell culture; micropopagation strategies and extra
vitro establishment, application of tissue culture in agriculture, horti-
culture, forestry and industry; plant transformation; transformation vec-
tors, concept of selectable and scorable markers; methods of transfor-
mation, Agrobacterium mediated transformation, binary vectors, biolitics,
electroporation, selection of putative transgenic plants, genetic analy-
sis, PCR, Southern analysis; evaluation of transgenic plants in contain-
ment facilities and field testing.

Practical

Photomorphogenesis effects (Red & Far red light) on few plant processes
- germination, chlorophyll synthesis, nitrate reductase activity; labora-
tory orientation and introduction of aseptic techniques; formulation of
media and sterilization; explants, preparation and inoculation; types of
cultures; methods of quantification of growth; induction of organogenesis
and clonal propagation; methods to obtain pathogen free plants; accli-
matization and extra vitro establishment; plant transformation vectors
and transformation of Agrobacterium strains; tobacco transformation
using leaf discs; visualisation of transiently expressed reporter genes;
characterisation of transgenic plants, PCR, Southern, Northern; main-
tenance of transgenic plants, under biosafety regulations.

Suggested Readings

George, E. F., (1993); Plant propagation by tissue culture, 2nd edition,

De Bergh, P. C. and Zimmerman, R. H., (1991); Micropropagation, tech-
nology and application, Kluwer Academic publishers, Dordrecht, Lon-
don.

Evans, D.A., Sharp, W. R., Ammirato, P. V. and Yamada, Y., (1983);
Hand Book of plant cell culture vol. I., Mc. Millan publishing company,
New York.

Srivastava, P.S. (1998); Plant Tissue Culture and Molecular Biology:
Applications and prospectus, Narosa Publishing house, New Delhi.

Bonga, J. M., Durzan, D.J. (1982); Tissue culture in forestry, Nizhoff /
junk, The Hauge.
A. 2. OPTIONAL COURSES

1. Crop physiology

Role of crop physiology in different branches of agriculture; crop growth and productivity, crop physiological processes influencing crop growth and productivity; crop growth models, describing yield (duncan / passioura); duncan's model; phenology, crop productivity, growth factors related to biomass-concept of crop growth rates, canopy photosynthesis (Leaf area and Net assimilation rates as determining factors); light interception as a major function of leaf area, LAI, LAD, canopy architecture, light extinction coefficient; net assimilation rate, variation in photosynthetic rates within and between the species; passioura's model; interrelation between total transpiration-WUE-plant growth, role of VPD; biomass and yield relations, partitioning of photosynthates at different growth stages of crop, harvest Index, yield and yield structure analysis; concept of source and sink, factors influencing source and sink size and productivity; environmental factors determining crop growth, light, temperature and VPD; effect of photoperiod and thermoperiod on duration of growth stages; idiotype concept, selection indices for improving crop productivity.

Suggested Readings


2. Plant growth regulators and plant development

Definition and classification of plant growth regulators, hormones, endogenous growth substances and synthetic chemicals; endogenous growth regulating substances other than hormones; brassinosteroids, triacontanol, phenols, polyamines, jasmonates, concept of death hormone; classification, site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth and development of individual group of hormones, auxins, gibberellins, cytokinins, abscisic acid and ethylene; concept of hormone action, hormone receptors and signal transduction; hormone mutants and transgenic plants in understanding role of hormones; hormonal regulation of gene expressions at various developmental stages of plant, flowering, seed maturity, seed dormancy; action of hormones on cellular functions; auxins, cell elongation, retardation of abscission of plant parts; gibberellins, stem elongation, germination of dormant seeds, cytokinins, cell division, retardation of senescence of plant parts, abscisic acid, stomatal closure and induction of drought resistance, ethylene, fruit ripening, acceleration of senescence of leaves; interaction of hormones in regulation of plant growth and development processes; rooting of cuttings, flowering, physiological and molecular aspects of control of reproductive growth; apical dominance, senescence and abscission; fruit growth and development; molecular aspects of controlling ripening processes and improving post harvest life of fruits, induction and breaking dormancy in seeds and buds; synthetic growth regulators, classification, their effect on plant growth and development, practical utility in agriculture and horticulture.

Practical

Quantification of hormones, principles of bioassays, physico-chemical techniques and immunoassay; extraction of hormones from plant tissue; auxins, bioassays, auxins effect on abscission, apical dominance; gibberellins, bioassays, GA effect on germination of dormant seeds; cytokinin, bioassays, estimation using immunoassay technique cytokinin effect on apical dominance and senescence; ABA bioassays; estimation using immunoassay techniques, ABA effect on stomatal movement; ethylene, bioassays, estimation using physico-chemical techniques, effect on breaking dormancy in sunflower and groundnut.

Suggested Readings


Weaver, R. J., (1972); Plant growth substances in agriculture W. H. Freeman, San Francisco.
3. **Physiological, molecular and ecological aspects of photosynthesis and productivity** (2+1)

Photosynthesis, its significance in crop productivity, eco-biomass, gaseous fluxes in atmosphere; historical summary of the photosynthetic processes; physiological and biochemical aspects; chloroplast structure and development, ultrastructure of thylakoids, photosystems, mechanism of light absorption, chloroplast electron transport chain, ATP synthesis, quantum yield concept; photosynthetic carbon reduction, supplementary carbon fixation pathways in C4 and CAM plants, their ecological significance, RuBisCO structure assembly and regulation, photorespiration and its significance; carbon fluxes between chloroplast and cytoplasm, Pi recycling, starch and sucrose synthesis and export; carbon fixation as a diffusive process, quantification of relative limitations, CO2 response curves, long term CO2 effects; concept of canopy photosynthesis, influence of environmental factors; molecular aspects; chloroplast genome organisation, expression and regulation of plastid genes; molecular analysis of rate limiting steps in carbon assimilation, antisense and gene expression studies; ecological aspect; productivity of different ecosystems, energy utilization efficiency in crop canopies; stress and high light; photo inhibition, photo oxidation, excitation energy dissipation mechanisms, generation and scavenging of active oxygen species, chlorophyll fluorescence as a diagnostic tool, photosynthesis and transpiration interaction, significance of WUE, carbon isotope discrimination concept; prospects of improving photosynthetic rate and productivity, potential traits of photosynthesis, biotechnological approaches.

**Practical**

Extraction, separation and estimation of plant pigments; isolation of chloroplasts, ETC reactions - O2 evolution; determination of RuBisCO
content (Western and **ELISA**), activity and activation state; enzymatic determination of starch and sucrose; determination of photosynthetic rates - gas exchange; $A$, $g_s$, $CI$, $A/g_s$, $Ci/gs$ - intrinsic WUE by gas exchange *rates;* light, CO-2, VPD response curves; determination of photorespiration by gas exchange - (TPS - APS); *genotypic/species differences* in photosynthetic rates; measurement of radiation, $E_u\%$, light interception;

**Suggested Readings**


Mohammad Yunus, Uday Pahtre, and Prasanna Mohanty, (2000); Probing Photosynthesis: Mechanisms, regulation and adaptation, Taylor and Francis, New York, USA.


4. Mineral nutrition: physiological and molecular aspects (1+1)

Historical aspects and importance of mineral nutrition in plant growth; classification and essentiality criteria; general mechanisms, concept of apparent free space and nature of bio-membranes; dual mechanism and other concepts of ion uptake; short distance transport, pathway from external solution (Apoplasm) to stele across the root cortical cells - factors contributing to xylem loading; long distance transport in xylem and phloem; xylem unloading in leaf cells; uptake and release of mineral nutrients by foliage; function of individual elements; rhizosphere and root biology, root growth, influence of micro-organism in nutrient acquisition, release and uptake by plant roots; yield and mineral nutrition, concept of nutrient use efficiency; mineral nutrition under adverse soil situations, drought, salinity acidity etc; heavy metal toxicity and concept of phytoremediation; molecular aspects, uptake and transport; role of transporter genes; genetics of nutrient uptake, identification and transfer of genes for tolerance to nutrient deficiencies, etc.

Practical

Growing plants in sand culture; preparation of synthetic nutrient solutions; raising of representative plants to demonstrate specific nutrient deficiency, differential uptake of ions, characterising deficiency symptoms; tissue analysis for nutrients.

Suggested Readings


5. **Seed physiology**

Structure of seeds and their storage resources; seed developmental patterns and source of assimilates for seed development; pathway of movement of assimilates in developing grains of monocots and dicots; chemical composition of seeds; storage of carbohydrates, proteins and fats in seeds; storage chemistry including biosynthesis; hydration of seeds; physiological processes; seed respiration, mitochondrial activity; mobilization of stored resource in seeds; chemistry of oxidation of starch, proteins and fats; utilization of breakdown products by embryonic axis; control processes in mobilization of stored resources; role of embryonic axes; gibberellin and \textbf{a-amylase} and other hydrolytic activity; seed maturation phase and desiccation damage; role of LEA proteins; seed viability; physiology of and means to prolong seed viability; seed dormancy, types and regulation; means to overcome seed dormancy.

**Practical**

Determination of seed storage proteins sink drawing ability of ovules, empty ovule technique; alpha-amylase activity in germinating seeds; role of GA in inducing amylase activity; role of embryo in GA induced a-amylase activity; protease and lipase activity in germinating seeds; seed viability test and accelerated ageing test; seed \textbf{hardening/osmotic} priming of seeds; estimation of seed respiration rates; seed viability losses, membrane leakage.

**Suggested Readings**


6. **Physiological aspects of crops - I** (2+0)*

Crop physiological aspects of rice, wheat, maize, sorghum, millets and sugarcane *species could be chosen based on local importance.

7. **Physiological aspects of crops - II** (2+0)*

Crop physiological aspects of pulses, oil seeds, cotton, tobacco and potato; crop *species could be chosen based on local importance.

8. **Climate variability, climate change and its impact on growth and productivity** (2+0)

Climate - past and present; analytical methods to determine long term changes in environment; Tree ring, cellulose stable carbon isotope discrimination, stable 18O discrimination for hydrological changes; likely changes in climate in future and its impact on crop and ecosystems; the green house gases and global warming; CO2 as an important green-house gas, global carbon deposits, fluxes in the sinks and sources; approaches to contain atmospheric CO2 level; effect of elevated CO2 on plant growth and development; basic processes and long term effect on growth; methane as a green house gas-sources, emission rates, chemistry nitrous oxide and the other green house gases; prediction on global warming, GCA models, effect on climate and biota; high temperature and CO2 interaction on plant growth and productivity; Ionising radiation UV-B; chlorinated flurocarbon (CFC), their impact on ozone layer-ozone hole and alteration in UV-B radiation; effect of UV-B radiation on plant ecosystem, repair and acclimation to UV-B damage; carotenoids and their role in membrane stabilisation; air pollutant, SO2, NO, methane, ozone, peroxy acetyl nitrate and their effect on ecosystem; Industrial and domestic effluents-theireffect on aquatic ecosystem, plant growth and developement.

**Suggested Readings**


Kimball, B. A., (1990), Impact of Carbon dioxide, Trace gases and Climate change on global agriculture, ASA, spec. publishers, Madison.

9. **Herbicide physiology**

Introduction, classification of herbicides; absorption and translocation of soil and foliar applied herbicides; physiological and biochemical effect of herbicides, effect on membrane structure and functions, on cell division and cell development; nature of herbicide receptor proteins and their role in herbicide tolerance; effect on chloroplast, photosynthesis, respiration, protein synthesis, synthesis of lipids; molecular mechanisms of herbicide resistance in relation to chloroplast gene expression; methods to increase the efficiency of soil and foliar applied herbicide, pH adjuvants, synergists; antidotes; case studies of different types of herbicides, growth regulating types, triazines, substituted ureas, chloroacetamides, substituted uracils; thiocarbamates, nitriles, bipyridylium, unclassified groups, herbicide mixtures; herbicide resistance, induction, taxonomic and biological consideration of herbicide resistance, nature of resistance to triazine, breeding herbicide tolerant crop cultivars; herbicide resistance in plant cell cultures, practical significance.

**Practical**

Bioassay for different herbicides; influence of pH, adjuvants, contact angle, Surface tension on penetration, absorption and translocation of herbicides; quantification of herbicide potency, relative potency; quanti-
fication of herbicide - herbicide interaction (synergistic, antagonistic and additive); role of adjuvants on penetration, translocation, contact angle surface tension etc; effect of herbicide on electron transport in isolated chloroplast and mitochondria; effect of herbicide on rate of photosynthesis in crop and weed plants.

**Suggested Readings**


Duke, S. O., (1984); Biochemical and physiological mechanism of herbicide action, American society of Plant Physiology.


**10. Physiology of flowering and reproduction (2+0)**

Evolutionary history of flowering plants (angiosperms); semelparous and iteroparous reproduction, monocarpic and perennial life habits etc; flowering phenomenon; effect of plant age, juvenility, transition to flowering; flowering nature and classification of plants; photoperiodic responses and the mechanisms in short and long day plants; theories related to (lowering; endogenous substances and flowering; gene expression in flowering; control of flowering, thermoperiodism, photo and thermoperiod interactions; vernalization, mechanism and practical use of the process; optimization in flowering response, to environmental features (light, temperature, stress) etc; plant reproductive physiology; mating strategies in plants, molecular techniques to understand mating patterns, self-incompatibility responses, physiological processes mediating fertilisation (pollen-stigma interactions), seed and fruit development, seed and fruit abortion and means to overcome it; molecular biology of seed development, physiological basis of cytoplasmic male sterility and fertility restoration; physiology of heterosis.

**Suggested Readings**

11. Physiology of horticultural and plantation crop species (2+0)

Growth and development of horticultural and plantation crop species; juvenility, shoot growth, types of shoots; patterns of shoot growth, cambial growth and its regulation; physiological aspects of pruning and dwarfing; growth measurements, water relations of tree species; water uptake and transport; concepts of transpiration ratio and water use efficiency; sexual and asexual propagation; root stock and scion interactions; physiology of flowering in perennial species, photoperiodism and thermoperiodism; physiological aspects of fruit crops, mango, banana, grapes, citrus, papaya and pineapple, etc; physiological aspect of plantation crops; coffee, tea, cardaman, coconut, pepper; NB species could be chosen based on the local importance.

Suggested Readings


12. **Post-harvest physiology** (1+1)

Senescence and ageing in plants; ethylene, the senescence hormone, leaf senescence, chloroplast degradations, monocarpic plant senescence; biochemistry and molecular biology of flower senescence; gene expression during senescence; concepts of physiological maturity of seeds, post harvest changes in biochemical constituents in field crops, loss of viability, loss of nutritive value (changes in fat deterioration etc.); environmental factors influencing post-harvest deterioration of seeds; post-harvest physiological and biochemical changes during fruit ripening and storage; senescence and post harvest of life and cut flowers; hormonal and chemical control of post-harvest deterioration of fruits, vegetables and cut flowers and its significance during storage and transport; regulation of fruit ripening at molecular level; transgenic technology for improvement of shelf life.

**Practical**

Physiological maturity indices, colour, softness and size of harvested fruits, mango, banana, sapota, apple, papaya, citrus and guava; changes in chlorophyll, storage protein, amino acids, membrane integrity during leaf senescence; use of antiethylene agents on petal senescence and vascular plugging during flower senescence; demonstration of ethylene and respiratory climatric in fruits; estimation of chlorophyll, colouring pigments, respiration and ethylene evolution during development, maturity and ripening stages; quantification of hydrolytic enzymes during ripening of fruits; judging TSS, acidity in fruits, estimation of quality and weight loss of fruits and vegetables during storage; estimation of sugars, vitamins, ascorbic acid and total phenolics.
Suggested Readings


13. **Experimental techniques in plant physiology** (0+2)

Determination of energy utilization of crop plants, growth structure analysis, radiation measurements and interception; photoperiodic responses, flowering regulation by light duration, quantification of photosensitive nature of a genotype; hydroponics and culture; quantification of hormone, immunoassay, physico-chemical methods; WUE; determination of water use efficiency by gravimetric approach; isotopes, use in physiological investigations (potential photosynthesis/protein synthesis); purification, quantification of RuBisCO by ELISA using polyclonal antibodies; gas exchange technique, measurement of photosynthetic rates and dark respiration; protein purification and isozyme analysis; moisture, temperature stress, methods to impose, quantification of the stress levels; molecular aspects of stress response, stress responsive proteins, their expression, Western and Northern analysis; stress measurement parameters (membrane integrity, chlorophyll stability index, osmolyte quantification, osmotic adjustment, TTC, etc.); xylem exudates as a measure of root activity and root signals; oxidative stress imposition and quantification; quantification of plant constituents; specific instruments to study different physiological processes, (Eg. Infrared thermometer, 1RGA, psychometry, neutron probe, atomic absorption spectrophotometer, liquid scintillation system).

Suggested Readings


Annexure-I

List of participants in meeting-cum workshop in the BSMA of Basic Science held on 5-6th March, 1999 at University of Agricultural Sciences, Bangalore-560065.

1. Dr. V. L. Chopra, Former DG, ICAR and National professor, IARI, New Delhi-110012.
2. Dr. S.L. Mehta, DDG(Edn.), ICAR, Krishi Anusandhan Bhawan, Pusa, New Delhi-110012.
3. Professor S.K. Sinha, Former Director, IARI and National Professor, IARI, New Delhi-110012.
4. Dr. RP. Sharma, Project Director, NRC, PB, IARI, New Delhi-110012.
5. Dr. M.L. Lodha, Head, Division of Biochemistry, IARI, New Delhi-110012.
6. Dr. M. Udaya Kumar, Professor & Head, Deptt. of Crop Physiology, UAS, GKVK, Bangalore.-560065.
7. Dr. S Sadasiviam, Director, CPMB, Tamil Nadu Agriculture University, Coimbatore-641003
9. Dr. A.C. Kapoor, Dean College of Basic Sciences, HPKVV, Palampur-163062.
10. Dr. G.P. Srivastava, Professor & Head, Deptt.of Agricultural Biochemistry, CSA University Of Agricultural and Technology, Kanpur.
11. Dr. R.C. Bohra, Head, Deptt. of Biochemistry, Assam Agricultural University, Jorhat-785013.
12. Dr. Geeta Ramchandra, Head, Deptt. of Biochemistry, University of Sciences, GKVVK Campus, Bangalore-560065.
13. Dr. G.C. Srivastava, Professor & Head, Deptt. of Plant Physiology, IARI, New Delhi-110012.
14. Dr. Thangaraj, Professor & Head, Crop Physiology, Tamil Nadu Agricultural University, Coimbatore-641003.
15. Dr. K. P. Das. Professor & Head, Deptt. of Crop Physiology, Orissa Agricultural University & Technology, Orissa.
16. Dr. A. Tyagi, Professor & Head, Deptt. of Plant Molecular Biology, University of Delhi, South Campus, New Delhi.
17. Dr. H. S. Nainavattee, Professor, Deptt. Of Biochemistry, CCS Haryana Agricultural University, Hisar-125004.
18. Dr. T.K. S. Gowoda, Deptt. Biotechnology, University of agriculture Sciences, GKVVK, Bangalore -560065.
19. Dr. K.R. Koundal, Professor, NRC, PB., IARI, New Delhi-110012.
20. Dr. B. D. Singh, Professor, School of Biotechnology, B.H. U., Varanasi.
21. Dr. Sharma, Professor, Deptt. of Crop Physiology, University of Udaipur.
22. Dr. T. G. Prasad, Professor, Deptt. of Crop Physiology, University of
Agricultural Sciences, GKVK, Banglore-560065.
23. Dr. V. R. Sashidhar, Associate Professor, University of Agricultural Sciences, GKVK, Banglore-560065.
24. Dr. I. S. Aftab Hussain, Associate Professor, Deptt. of Crop Physiology, University of Agricultural Sciences, GKVK, Banglore-560065.
25. Dr. R. Devendra, Professor, Deptt. of Crop Physiology, University of Agricultural Sciences, GKVK, Banglore-560065.
26. Dr. Vedpal Singh Malik, Biotechnologist, USDA, USA.
Annexure-II

List of participants in meeting-cum workshop in the BSMA of Basic Science (Microbiology) held on 25-26th Sept., 2000 at Tamil Nadu Agricultural University, Coimbatore-641003.

1. Dr. S Kannaiyan, Vice-Chancellor, Tamil Nadu Agricultural University, Coimbatore-641003.
2. Dr. D. J. Bagyaraj, Professor & Head, Dept. of Microbiology, University of Agricultural Sciences, GKVK, Bangalore-560065.
3. Dr. M.D. Sundaram, Professor & Head, Dept. of microbiology, Faculty of Agriculture, Annamalai University, Annamalai Nagar-608002.
4. Dr. K. Govindarajan, Dept. of Microbiology, Tamil Nadu Agricultural University, Coimbatore-641003.
5. Dr. S. P. Sundaram, Professor, Dept. of Microbiology, Tamil Nadu Agricultural University, Coimbatore-641003.
6. Dr. K. Kumar, Assoeate Professor, Tamil Nadu Agricultural University, Coimbatore-641003.
7. Dr. G. Gopalaswamy, Associate Professor, Dept. of Microbiology, Tamil Nadu Agricultural University, Coimbatore-641003.