

## **01. AGRICULTURAL BIOTECHNOLOGY**

### **Unit 1: Cell Structure and Function**

Prokaryotic and eukaryotic cell architecture, Cell wall, plasma membrane, Structure and function of cell organelles: vacuoles, mitochondria, plastids, golgi apparatus, ER, peroxisomes, glyoxisomes. Cell division, regulation of cell cycle, Protein secretion and targeting, Cell division, growth and differentiation.

### **Unit 2: Biomolecules and Metabolism**

Structure and function of carbohydrates, lipids, proteins and nucleic acids, Synthesis of carbohydrate, glycolysis, HMP, Citric acid cycle and metabolic regulation, Oxidative phosphorylation and substrate level phosphorylation, Vitamins, plant and animal hormones. Functional molecules, antioxidants, nutrient precursor, HSPs, anti-viral compounds.

### **Unit 3: Enzymology**

Enzymes, structure conformation, classification, assay, isolation, purification and characterization, catalysis specificity, mechanism of action, active site, regulation of enzyme activity, multienzyme complexes, immobilized enzymes and protein engineering, immobilized enzymes and their application.

### **Unit 4: Molecular Genetics**

Concept of gene, Prokaryotes as genetic system, Prokaryotic and eukaryotic chromosomes, methods of gene isolation and identification, Split genes, overlapping genes and pseudo genes, Organization of prokaryotic and eukaryotic genes and genomes including operon, exon, intron, enhancer promoter sequences and other regulatory elements. Mutation – spontaneous, induced and site-directed, recombination in bacteria, fungi and viruses, transformation, transduction, conjugation, transposable elements and transposition.

### **Unit 5: Gene Expression**

Expression of genetic information, operon concept, Transcription – mechanism of transcription in prokaryotes and eukaryotes, transcription unit, regulatory sequences and enhancers, activators, repressors, co-activators, Co-repressors in prokaryotes and eukaryotes, inducible genes and promoters, Transcription factors post transcriptional modification and protein transport, DNA-protein interaction, Genetic code. Mechanism of translation and its control, post translational modifications.

### **Unit 6: Molecular Biology Techniques**

Isolation and purification of nucleic acids. Nucleic acids hybridization: Southern, northern and western blotting hybridization. Immune response monoclonal and polyclonal antibodies and ELISA, DNA sequencing. Construction and screening of genomic and C-DNA libraries. Gel electrophoretic techniques. Polymerase chain reactor spectroscopy, rtPCR ultracentrifugation, chromatography, FISH, RIA etc.

### **Unit 7: Gene Cloning**

Restriction enzymes and their uses. Salient features and uses of most commonly used vectors i.e. plasmids, bacteriophages, phagmids, cosmids, BACs, PACs and YACs, binary vectors, expression vectors. Gene cloning and sub-cloning strategies, chromosome walking, genetic transformation, Basis of animal cloning. Biology. Risk assessment and IPR.



**Unit 8: Molecular Biology**

Ribosome structure and function. Protein biosynthesis in prokaryotes and eukaryotes. Post-translational modification. Gene regulation, RNA processing and Post transcriptional modifications. Bioprospecting, biofortification, gene pyrimiding and gene fusion, nbozyme technology.

**Unit 9: Plant Molecular Biology**

Photoregulation and phytochrome regulation of nuclear and chloroplastic gene expression. Molecular mechanism of nitrogen fixation. Molecular biology of various stresses, viz. abiotic stresses like drought, salt, heavy metals and temperature; and biotic stresses like bacterial, fungal and viral diseases. Signal transduction and its molecular basis, molecular mechanism of plant hormone action mitochondrial control of fertility, structure, organization and regulation of nuclear gene concerning storage proteins and starch synthesis.

**Unit 10: Tissue Culture**

Basic techniques in cell culture and somatic cell genetics. Regulation of cell cycle and cell division.. Clonal propagation. Concept of cellular totipotency. Anther culture, somaclonal and gametoclonal variations. Hybrid embryo culture and embryo rescue, somatic hybridization and cybridization. Application of tissue culture in crop improvement. Secondary metabolite production. *In vitro*, mutagenesis, cryopreservation and plant tissue culture repository.

**Unit 11: Plant Genetic Engineering**

Isolation of genes of economic importance. Gene constructs for tissue-specific expression. Different methods of gene transfer to plants, viz. direct and vector-mediated. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement, i.e. insect-pest resistance (insect, viral, fungal and bacterial disease resistance), abiotic stress resistance, herbicide resistance, storage protein quality, increasing shelf-life, oil quality, Current status of transgenics, biosafety norms and controlled field trials and release of transgenics (GMOs).

**Unit 12: Molecular Markers and Genomics**

DNA molecular markers: Principles, type and applications; restriction fragment length polymorphism (RFLP), amplified fragment length polymorphism (AFLP), randomly amplified polymorphic DNA sequences (RAPD), Simple sequence repeats (SSR), Single nucleotide polymorphism (SNP), Structural and functional genomics, gene mapping, genome mapping, gene tagging and comparative genomics and application of genomics.



## **02. AGRICULTURAL ENTOMOLOGY**

### **Unit 1: Systematics**

History and development of Entomology, Evolution of insects, position of insects in the animal world, characteristics of phylum Arthropoda, structural features of important arthropod groups such as Trilobita, Chelicerata and Mandibulata, structural features of important classes of phylum Arthropoda viz. Arachnida, Crustacea, Chilopoda, Diplopoda and Hexapoda. Classification of insects up to order level, habits, habitats and distinguishing features of different Order and important Families.

### **Unit 2: Morphology**

Body wall, its structure, outgrowths, endoskeleton, Body regions, segmentation, sclerites and sutures. Head and head appendages, types of mouth parts, antennae, their structure and types. Thorax structure, thoracic appendages and their modification. Wings, their modification and venation, Abdomen; structure, abdominal appendages both in Pterygota and Apterygota. External genitalia, general structure and modification in important insect orders.

### **Unit 3: Embryology, Internal Anatomy and Physiology**

Embryonic and post embryonic development, types of metamorphosis, physiology of ecdysis. General features and types of larvae and pupae. Structure, function and physiology of Digestive, Circulatory, Respiratory, Reproductive, Nervous and Excretory systems, Sense Organs; structure and types. Insect food and nutrition; minerals, carbohydrates, proteins and amino acids, lipids, vitamins and their role in growth and development, artificial diets.

### **Unit 4: Ecology**

Concept of ecology, Environment and its components-biotic and abiotic factors and their effects on growth, development, population dynamics, distribution and dispersal. Principle of biogeography and insects biodiversity. Biotic potential and environmental resistance. Ecosystems, agroecosystems analysis, their characteristics and functioning. Intra and inter specific relationship; competition, predator-prey and host-parasite interactions, ecological niche. Life table studies, population models. Food chain and food web. Arthropod population monitoring, pest forecasting. Diapause and causes of pest out breaks.

### **Unit 5: Biological Control**

Importance and scope of biological control, history of biological control: Biocontrol agents-parasites, predators and insect pathogens. Important entomophagous insect Orders and Families. Ecological, biological, taxonomic, legal and economic aspects of biological control, phenomena of multiple parasitism, hyperparasitism, superparasitism and their applied importance. Principles and procedures of using exotic biocontrol agents. Utilization of natural biocontrol agents: conservation, habitat management and augmentation. Mass multiplication techniques and economics. Effective evaluation techniques, Biocontrol organizations in world and India. Successful cases of biological control of pests.

### **Unit 6: Chemical Control and Toxicology**

History, scope and principles of chemical control. Insecticides and their classification. Formulations of insecticides. Susceptibility of insects to the entry of insecticides. Physical, chemical and toxicological properties of different groups of insecticides: chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids, chlordimeform, chitin synthesis inhibitors, avermectins, nitroguanidines, phenylpyrrozzoles, botanicals (natural pyrethroids, rotenone, neem products, nicotine, pongamia spp. etc). Combination insecticides. Problems of pesticide hazards and



environmental pollution. Safe use of pesticides, precautions and first aid treatments. Insecticides Act 1968, registration and quality control of insecticides.

Evaluation of toxicity, methods of toxicity testing, determination of LD<sub>50</sub>, LT<sub>50</sub>, RL<sub>50</sub> etc. Pesticides residues in the environment and their dynamics of movements, methods of residue. Pharmacology of insect poisons. Mode of action of different groups of insecticides; neuroactive (axonal and synaptic) poisons, respiratory poisons, chitin synthesis inhibitors. Metabolism of insecticides; activative and degradative metabolism, detoxification enzymes and their role in metabolism. Selectivity of insecticidal actions; insecticide resistance; mechanism, genetics and management of insecticide resistance.

#### **Unit 7: Host Plant Resistance**

Chemical ecology: mechano and chemo receptors. Host plant selection by phytophagous insects. Secondary plant substances and their defenses against phytophagous insect. Basis of resistance (Antixenosis, Antibiosis, Tolerance). Biotypes development and its remedial measures. Tritrophic interactions, induced resistance. Breeding for insect resistant plant varieties. Resistance development and evaluation techniques. Genetics of Resistance: vertical resistance, horizontal resistance, oligogenic resistance, polygenic resistance. Biotechnological approaches and development of transgenic insect resistant plants, its advantages and limitations. Case histories. Insect resistance to transgenic plants and its management.

#### **Unit 8: Innovative Approaches in Pest Control**

Behavioral control: pheromones-types and uses, advantages and limitations. Hormonal control: types and function of insect hormones, insect hormone mimics, advantages and limitations. chemosterilants, antifeedants, attractants, repellents; their types, method of applications, advantages and limitations. Genetic control: concepts and methods, case histories, advantages and limitations. Potentialities of IPM.

#### **Unit 9: Integrated Pest Management**

History, concept and principles of IPM. Components of IPM: Host plant resistance, agronomic manipulations, mechanical and physical methods, chemical methods, biocontrol agents utilization, genetic and behavioral control strategy etc. IPM strategies for field and horticultural crops. IPM case histories. Concept of damage levels- Economic threshold levels (ETL), Economic injury levels (EIL) and their determination. System approach, Agro ecosystem and cropping system *vs.* IPM. Constraints and Strategies of IPM implementation.

#### **Unit 10: Pesticide Application Equipments**

Types of appliances: sprayers, dusters, fog generators, smoke generators, soil injecting guns, seed treating drums, flame throwers, etc. Power operated sprayers and dusters. Types of nozzles and their uses. Maintenance of appliances. Aerial application of pesticides, principles of aerial application, factors affecting the effectiveness of aerial application. Equipments for aerial applications. Advantages and disadvantages of aerial application.

#### **Unit 11: Pests of Field Crops and their Management**

Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of cereals, Oilseed, pulses and fibre crops, sugarcane and tobacco. Polyphagous pests: locusts, termites, hairy caterpillars, cut worms and white grubs.

#### **Unit 12: Pests of Horticultural Crops and their Management**

Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of vegetables, fruits and plantation crops, spices, condiments and ornamentals.



### **Unit 13: Pests of Stored Products and their Management**

Fundamentals of storage of grains and grain products. Storage losses, sources of infestation/infection, factors influencing losses, insect and non-insect pests, their nature of damage and control. Microflora in storage environment and their control. Storage structures, bulk storage and bag storage, their relative efficacy and demerits. Grain drying methods and aeration. Non-insect pests (rodents, birds, mites) of stored products and their control. Integrated management of storage pests.

### **Unit 14: Arthropod Vectors of Plant Diseases**

Common arthropod vectors viz., aphids, leaf hoppers, plant hoppers, whiteflies, thrips, psyllids, beetles, weevils, flies, bees and mites and their relationship with the plant pathogenic fungi, bacteria, viruses, mycoplasma. Mechanism of pathogen transmission : Active mechanical transmission, biological transmission. Toxicogenic insects, mites and phytotoxemia. Some important arthropod vector transmitted diseases and their epidemiology in India. Management of vector and its effect on control of diseases.

### **Unit 15: Honey Bees and Bee-keeping**

Honey bees and their economic importance. Bee species, their behaviour, habit and habitats. Bee Keeping: bee pasturage, hives and equipments, seasonal management. Bee enemies including diseases and their control.

### **Unit 16: Silkworms and Sericulture**

Silkworm species, their systematic position and salient features. Rearing techniques of mulberry-muga-eri and tassar silkworms. Nutritional requirements of silkworms. Sericulture: rearing house and appliances, silkworm breeds, principles of voltinism and bivoltinism, seed production and its economics. Enemies and diseases of silkworms and their management. Sericulture organization in India.

### **Unit 17: Lac Insect**

Lac insect, its biology, habit and habitats. Host Trees: pruning, inoculation, lac cropping techniques, and harvesting. Enemies of lac insect and their control.

**Unit 18: Other Useful Insects** Pollinators, biocontrol agents of weeds, soil fertility improving agents, scavengers. Use of insects and insect products in medicines. Usefulness of insects in scientific investigations, insects as food.

### **Unit 19: Statistics and Computer Application**

Frequency distribution, mean, mode and median. Standard, normal, binomial and Poisson's distribution, Sampling methods and standard errors. Correlation and regression: Partial and multiple, tests of significance; t, F, chi-square, Duncan's multiple range tests. Design of experiments: Principles of Randomized block design, Completely r

andomized block design, Latin square design, Split-plot designs. Probit analysis. Use of soft ware packages like SPSS, SAS, etc. for the above tests and designs of experiments for analysis.



### **03. AGRICULTURAL MICROBIOLOGY**

#### **Unit 1: History of Microbial World**

History, development and scope of microbiology, evolution of microbial life. Theory of spontaneous generation. Prokaryotes, archaeobacteria and eukaryotes. Techniques used in identification and classification of bacteria. Important groups of prokaryotes – photosynthetic bacteria, blue green algae, chemoautotrophic bacteria, spore forming bacteria, mycoplasma, viruses, bacteriophages and actinomycetes. Heterotrophic bacteria nitrobacteria, nitrogen-fixing bacteria and cyanobacteria, lactic acid bacteria, halophiles, thermophiles acidophiles and methanogens. Structure and classification of viruses, growth of viruses, lytic and lysogenic cycles, plant viruses, viroids.

#### **Unit 2: Microbial Ecology and Physiology**

Principles of microbial ecology, Microbiology of ecosystems - soil, rhizosphere, phyllosphere, water - fresh and marine, and air. Microbial interactions - symbiosis, synergism, commensalism, parasitism, amensalism, antagonism and predation, adoption of micro-organisms to various ecosystems. Microbial growth curve. Mathematical expression of growth -continuous and batch cultures. Diauxic and synchronous growth. Microbial nutrition. Bacterial metabolism - aerobic and anaerobic respiration, electron transport chain, microbial photosynthesis, oxidative and substrate level photo-phosphorylation. Biosynthesis of cell wall, protein breakdown by microbes.

#### **Unit 3: Soil Microbiology**

Soil microorganisms: major groups, decomposition of organic matter, soil health. Root exudates and rhizosphere effects. Manipulation of rhizosphere microflora in plant productivity. Microbial biomass. Nitrogen cycle: ammonification, nitrification and denitrification. Biological nitrogen fixation-symbiotic and asymbiotic. Biochemistry and genetics of nitrogen fixation. Microbial transformations of phosphorus, sulphur and minor nutrients. Role of bio-fertilizers in agriculture and forestry. Bioremediation of problem soils, plant growth promoting rhizobacteria and their mode of action. Formation and composition of soil organic matter: fulvic acid and humic acid.

#### **Unit 4: Environmental Microbiology and Basic Microbiological Techniques**

Isolation and preservation of different types of microorganisms. Methods of sterilization and disinfection. Microscopy: Optical, phase contrast, fluorescent, dark field and electron. Microbial assay of vitamins, enzymes and antibiotics, Pollution of soil, water and air, Role of microorganisms in pollution, sources of pollution and their impact on environment, microbiology of sewage and industrial effluents and their safe disposal, management of solid and liquid organic wastes, composting, biogas, water purification, sewage treatment, water-borne diseases and effluent management.

#### **Unit 5: Microbial Biotechnology**

Industrial production of metabolites - organic acids, alcohols, antibiotics. Fermentor designs and types. Control of fermentation process - batch, feed batch and continuous. Downstream processing in fermentation industry. Production of single cell proteins and probiotics, hormones, biofertilizers, biopesticides. Phyto-remediation. Microbiology of raw and processed foods. Fermented food – vinegar, wine sauerkraut, pickles, cheese, yogurt. Food preservation, contamination and spoilage, food-borne illness and intoxication. Food as substrate for micro-organism, microflora of meat, fish, egg, fruits, vegetables, juices, flour, canned foods; bio-degrading microbes, single cell protein for use as food and feed, bioactive food / probiotics



## **04. ECONOMIC BOTANY & PLANT GENETIC RESOURCES**

### **Unit 1 : Plant Taxonomy and Biosystematics**

Nomenclature, purpose, principles and systems of classification; Taxonomy of higher plants, floras, manuals, monographs, index, catalogues and dictionaries, herbaria; Concepts of biosystematics, evolution and differentiation of species; Biosystematic and taxonomic tools; Origin, evolution and biosystematics of selected crops (rice, wheat, rape seed & mustard, cotton).

### **Unit 2 : Economically important plants –I**

Origin, history, domestication, botany, genetic resource activities, cultivation, production and use of:

Cereals: Wheat, rice, maize, sorghum, pearl millet and minor millets.

Pulses: Pigeon pea, chickpea, black gram, green gram, cowpea, soyabean, pea, lentil, horsegram, lab-lab bean, ricebean, winged bean, French bean, lima bean, sword bean.

Oilseeds: Groundnut, sesame, castor, rape seed, mustard, sunflower, safflower, niger, oil palm, coconut and linseed.

### **Unit 3 : Economically important plants –II**

Origin, distribution, cultivation, production and utilization of economic plants of following groups such as Fibres: cotton, silk cotton, jute, sunnhemp, agave, flax and mesta (kenoff); Sugars: sugarcane, sugarbeet, sugarpalm and sweet sorghum; Fodders and green manure crops: Plantation crops: coconut, cocoa, tea; root and tuber crops: potato, sweet potato, tapioca, aroids etc.

### **Unit 4 : Economically important plants –III**

Origin, distribution, classification, production and utilization of Fruits: mango, banana, citrus, guava, grapes and other indigenous fruits; apple, plum, pear, peach, cashewnut and walnut; Vegetables: tomato, brinjal, okra, cucumber, cole crops, gourds etc.; Fumigatories and masticatories: tobacco, betelvine, arecanut; medicinal and aromatic plants: sarpagandha, belladonna, cinchona, nux-vomica, vinca, mentha and glycyrrhiza, plantago etc.; Narcotics: cannabis, datura, gloriosa, pyrethrum and opium; Dye-, tannin-, gum- and resin- yielding plants; Plant of agro-forestry importance: multipurpose trees/shrubs, subabool, *Acacia nilotica*, poplar, sesbania, neem etc.; non-traditional economic plants: jojoba, guayule, jatropha, carcus etc.

### **Unit 5 : Biodiversity and Plant Genetic Resources (PGR)**

Biosphere and biodiversity; plant species richness and endemism; concept and importance of plant genetic resources and its increasing erosion; Centres of origin and diversity of crop plants, domestication, evaluation, bioprospecting; National and International organizations associated with PGR; Convention on Biological Diversity (CBD), recent issues related to access and ownership of PGR, IPR, PBRs, farmers rights, *sui-generis* system etc.

### **Unit 6 : Germplasm Augmentation**

History and importance of germplasm collection, ecogeographical distribution of diversity, logistics of exploration and collection, use of flora and herbaria, random and selective sampling, genepool sampling in self and cross pollinated species; Concept, importance and ecogeographical considerations of introduction and exchange of plant germplasm; prerequisites conventions and achievements of PGR exchange.



**Unit 7 : Germplasm Conservation**

Principles and methods of conservation, *in situ* and *ex situ* methods, on – farm conservation; Gene banks: short-medium- and long-term conservation strategies; seed physiology and seed technology in conservation; seed storage behaviour (orthodox, recalcitrant), field genebanks, clonal repositories. Gene bank management, gene bank standard for various crops, ISTA, AOSA, IPGRI guidelines, documentation of information in gene bank.

**Unit 8 : Biotechnology in PGR**

Plant conservation biotechnology, biotechnology in plant germplasm acquisition; plant tissue culture in disease elimination, *in vitro* conservation and exchange; cryopreservation, transgenics – exchange and biosafety issues; biochemical and molecular approaches to assessing plant diversity.

**Unit 9 : Plant Quarantine**

Principles, objectives and relevance of plant quarantine; Regulations and plant quarantine set up in India; economic significance of seed borne pests, pathogens and weeds; detection and post entry quarantine operations, salvaging of infested/infected germplasm, domestic quarantine.

**Unit 10 : Germplasm characterization, evaluation, maintenance and regeneration**

Principles and strategies of PGR evaluation, approaches in germplasm characterization and diversity analysis, concept of core collection, descriptors and descriptor states for data scoring; maintenance of working and active collections of self-cross-pollinated and vegetatively propagated crops, perennials and wild relatives; principles and practices of regeneration in relation to mode of reproduction, concept of genetic integrity, genetic shift, genetic drift and optimum environment; post-harvest handling of germplasm; PGR data base management.



## **05. Genetics & Plant Breeding**

### **Unit 1: General Genetics and Plant Breeding**

Mendelian inheritance. Cell structure and division, Linkage, its detection and estimation. Epistasis. Gene concept, allelism and fine structure of gene. Extra chromosomal inheritance. DNA – structure, function, replication and repair. Genetic code. Gene- enzyme relationship. Replication, Transcription and Translation. Gene regulation in prokaryotes and eukaryotes. Nuclear and cytoplasmic genome organization. Spontaneous and induced mutations and their molecular mechanisms. Crop domestication, evolution of crops and centres of diversity. Emergence of scientific plant breeding. Objectives and accomplishments in plant breeding and the role of National and International institutes. Gametogenesis and fertilization. Modes of sexual and asexual reproduction and its relation to plant breeding methodology. Apomixes, incompatibility and male sterility systems and their use in plant breeding.

### **Unit 2: Economics Botany and Plant Breeding Methods**

Origin, distribution, classification, description and botany of cereals (wheat, rice, maize, sorghum, pearl millet, minor millets); pulses (pigeonpea, chickpea, black gram, green gram, cowpea, soyabean, pea, lentil, horse gram, lab-lab, rice bean, winged bean, lathyrus, Lima bean; oilseeds (groundnuts, sesamum, castor, rapeseed mustard, sunflower, Niger, linseed); fibers and sugar crops, fodder and green manures; Breeding methods for self-pollinated, cross-pollinated and clonally propagated crops. Component, recombinational and transgressive breeding. Single seed descent. Populations, their improvement methods and maintenance, Hybrid breeding and genetic basis of heterosis. Ideotype breeding. Mutation breeding.

### **Unit 3: Genome organization and Cytogenetics of Crop Plants**

Chromosome structure, function and replication. Recombination and crossing over. Karyotype analysis. Banding techniques. *In situ* hybridization. Special types of chromosomes. Chromosomal interchanges, inversions, duplications and deletions. Polyploids, haploids, aneuploids and their utility. Wide hybridization and chromosomal manipulations for alien gene transfer. Pre-and post- fertilization barriers in wide hybridization. Genome organization and cytogenetics of important crop species- wheat, maize, rice, Brassica, cotton, Vigna, potato and sugarcane. Principles and procedures of genome analysis. Cytogenetic techniques for gene location and gene transfer, Construction and use of molecular marker based chromosome maps. Comparative mapping and genome analysis.

### **Unit 4: Quantitative and Biometrical Genetics**

Quantitative characters. Multiple factors inheritance. Genetic control of polygenic characters. Genetic advance and types of selection and correlated response. Hardy Weinberg law. Linkage disequilibrium. Genetic load. Polymorphism. Breeding value, heritability. Response to selection, correlated response. Estimates of variance components and covariance among relatives. Mating designs with random and inbred parents. Estimation of gene effects and combining ability. Effects of linkage and epistasis on estimation of genetic parameters. Maternal effects. Genotype-environment interactions and stability of performance. Heterosis and its basis. Mating system and mating design- diallel, line X tester, NC-1, NC-II and NC-III designs, approaches to estimate and exploit component of self and cross pollinated crops. Genotype X environment interaction and stability analysis.



**Unit 5: Genetic Engineering and Biotechnological Tools in Plant Breeding**

Somatic hybridization, micropropagation, somachonal variation *in vitro* mutagenesis. Artificial synthesis of gene. Genetic and molecular markers, generations of molecular markers and their application in genetic analyses and breeding. Molecular markers in genetic diversity analysis and breeding for complex characters. Gene tagging, QTL mapping and marker aided selection. Genome projects and utilization of sequence formation. Vectors. DNA libraries, DNA fingerprinting, DNA sequencing. Nuclei acid hybridization and immunochemical detection. Chromosome walking, Recombinant DNA technology, Gene cloning strategies. Genetic transformation and transgenics. Antisense RNA, RNAi and micro RNA techniques in crop improvement.

**Unit 6: Plant Breeding for Stress Resistance and Nutritional Quality**

Genetic basis and breeding for resistance to diseases and insect-pests. Breeding for vertical and horizontal resistance to diseases. Genetic and physiological basis of abiotic stress tolerance. Breeding for resistance to heat, frost, flood, drought and soil stresses. Important quality parameters in various crops, their genetic basis and breeding for these traits. Role of molecular markers in stress resistance breeding: MAS, MARS and MABB.

**Unit 7: Plant Genetic Resources and their Regulatory System; Varietal Release and Seed Production**

Plant exploration, germplasm introduction, exchange, conservation, evaluation and utilization of plant genetic resoures. Convention on Biological Diversity and International Treaty on Plant Genetic Resources for Food and Agriculture. Intellectual Property Rights. Biodiversity Act. Plant Variety Protection and Farmers' Rights Act. System of variety release and notification. Types of seeds and seed chain. Seed production and certification.

**Unit 8: Statistical Methods and Field Plot Techniques**

Frequency distribution. Measures of central tendency, probability theory and its applications in genetics. Probabaility distribution and tests of significance. Correlation, linear, partial and multiple regression. Genetic divergence. Multivariate analysis. Design of experiments- basic principles, completely randomized design, randomized block design and split plot design. Complete and incomplete block designs. Augmented design, Grid and honeycomb design. Hill plots, unreplicated evaluation. Data collection and interpretation.



## **06. NEMATOLOGY**

### **Unit 1: History and Economic Importance**

History and economic importance of nematology; Diseases caused by plant-parasitic nematodes-symptomatology, biology, distribution and management of plant parasitic nematodes of economic importance (*Pratylenchus*, *Radopholus*, *Hirschmanniella*, *Meloidogyne*, *Heterodera*, *Globodera*, *Rotylenchulus*, *Tylenchulus*, *Ditylenchus*, *Anguina*, *Aphelenchoides*, *Tylenchorhynchus*, *Helicotylenchus*, *Hoplolaimus*, *Scutellonema*, *Paratylenchus*, etc.). Entomopathogenic nematodes.

### **Unit 2 : Nematode Taxonomy and Morphology**

Principles and concepts of taxonomy. Rules of nomenclature. Nematode phylogeny and systematics. Classification of soil and plant -parasitic nematodes and their relationships with other related phyla. Detailed classification of plant - parasitic nematodes up to generic level with emphasis on genera of economic importance. General morphology and anatomy of nematodes. Various systems: digestive,, excretory, nervous, reproductive etc., developmental biology of nematodes.

### **Unit 3 : Nematological Techniques**

Methods of extraction of nematodes from soil and plant material. Microscopy - principles and types including electron microscopes. Methods of killing, fixing, preserving, staining, mounting and measuring of nematodes. Techniques for histopathology and culturing of nematodes - plant parasitic, entomophilic and saprophytic including axenic methods. Experimental techniques for proving pathogenicity, estimation of crop losses, nematicide screening, screening and evaluation for nematode resistance in crops. Molecular technique for nematode diagnostics. Techniques for mass culturing of nematode antagonistic bioagents.

### **Unit 4 : Nematode Ecology**

Ecological classification and distribution of nematodes. Mode of nematode dispersal. Adaptations to parasite mode of life. Soil as environment for nematodes. Effect of biotic and abiotic factors on nematode survival, activity and reproduction. Nematode population dynamics. Nematode -induced plant damage and modeling. Community analysis.

### **Unit 5 : Plant Nematode Relationships**

Types of parasitism in nematodes. Nature of damage caused by various groups of plant parasitic nematodes and mechanisms involved. Pathotypes in nematodes. Mechanism of nematode resistance and tolerance in plants and its assessment. Physiological, biochemical and molecular changes in plants due to nematode infections.

### **Unit 6 : Nematode Physiology and Cytology**

Chemical composition of nematodes. Principles of nematode physiology. Physiological functions of cell; organelles. Physiology of respiration, digestion, excretion, reproduction, growth and development. Physiology of muscular, nervous and sensory responses. Physiology of moulting, hatching and nematode survival. Chemoreception in nematodes. Nematode as biological models - *Caenorhabditis elegans*. Cytological changes in plants due to infection including syncytia, giant cell formation and their modification etc.



**Unit 7 : Nematode Management**

Principles and methods of nematode management - physical, cultural biological, chemical and legislative, Nematicides (including those of biological origin) - history, classification, formulations, application and mode of action. Host resistance for nematode management. Integrated nematode management. Role of biotechnology in nematode management.

**Unit 8 : Interactions of Nematodes with Soil Organisms**

Importance of interactions (interrelationships) of nematodes with soil organisms. Interactions of nematodes with bacteria, fungi, viruses, mycorrhizae and other nematodes. Nematodes as vectors of viruses and other microorganisms.

**Unit 9 : Statistics**

Frequency distribution. Measures of central tendency and dispersion: mean, median, mode, standard deviation etc. Population distributions : normal, binomial and poisson. Correlations: partial and multiple. Tests of significance: t, F and Chi square and randomized block, Latin square and split plot designs, their analysis and interpretation.



## **07. PLANT BIOCHEMISTRY**

### **Unit 1: Basic Biochemistry and Biomolecules**

Scope and importance of biochemistry and molecular biology in plants. Structural and functional organization of prokaryotic and eukaryotic cells, viruses and bacteriophages, cell organelles function and their fractionation. Chemical bonding in biological systems, pH and buffers. Thermodynamics and bioenergetics- concept of entropy, and free energy changes in biological reactions, Redox reactions, Role of high energy phosphates. Biomembranes. Classification structure, chemistry, properties and function of carbohydrates, proteins, lipids and nucleic acids. Components of immune system, Prostaglandins.

### **Unit 2: Intermediary Metabolism**

Anabolism, catabolism and their regulation. Metabolism of carbohydrates – glycolytic pathway, HMP pathway, TCA cycle, glyoxylate pathway and gluconeogenesis. Biological oxidation- electron transfer and oxidative phosphorylation. Lipid metabolism, degradation and biosynthesis of fatty acids, ketogenesis and causes of ketosis. Biosynthesis of sterols and phospholipids. Amino acid metabolism – catabolism of amino acids, transamination and deamination, urea cycle, biosynthesis of amino acids. Conversion of amino acids into bioactive compounds. Metabolism of nucleic acids-degradation and biosynthesis of purines, pyrimidines and nucleotides. Integration of carbohydrate, lipid and amino acid metabolism. Signal transduction mechanisms. Role of G-proteins, cyclic nucleotides and calcium in transduction. Disorders of lipid, carbohydrate, nucleic acid, amino acid metabolism. Inborn errors of metabolism. Secondary metabolites, biotransformation and over expression.

### **Unit 3: Enzymes, Vitamins and Hormones**

Major classes of enzymes, general properties, kinetics, active site and its mapping, activation energy and transition state. Mechanisms of enzyme action, inhibition and activation. Coenzymes and cofactors. Isoenzymes and immobilized enzymes. Regulation of enzyme activity, allosteric regulation. Multi substrate reactions, kinetic experiments to determine the mechanism of multi substrate reactions. Isolation, purification and measurement of enzyme activity. Enzyme units. Enzyme engineering. Role of enzymes in agriculture, industry, and medicine. Structure, mode of action and metabolic functions of vitamins. Deficiency diseases associated with vitamins. General description of nature hormones and disorders associated with endocrine glands, viz. pituitary, thyroid, adrenal, pancreas and gonads. Peptide and steroid hormones. Phyto hormones – auxins, gibberellins, cytokinins, ethylene, abscisic acid and new plant bio-regulators like SA, Brassinolide.

### **Unit 4: Molecular Biology**

Structure of DNA and RNA Replication, transcription and translation. Post-transcriptional and translational modifications. Transcriptional and translation control of prokaryotes and eukaryotes. Features of genetic code in prokaryotes and eukaryotes. Gene expression - operon model, induction and repression, control of gene expression in prokaryotes and eukaryotes. Chloroplast and Mitochondrial genomes. Replication of viruses. Mutagens, oncogenes and carcinogenesis. General principles of recombinant DNA technology, restriction enzymes. Methods of gene transfer-plasmid and viruses as vectors, DNA and protein sequence analysis, oligonucleotide synthesis, genomic and cDNA library construction, site-directed mutagenesis, transposon tagging, chromosome walking. Basics of genome organization and mapping, functional genomics. Gene silencing. Methods for the development of transgenic organisms. Computer application in molecular biology, primer designing, sequence analysis and



phylogenetic analysis. Benefits of gene manipulation in agriculture, nanobiotechnology, bio-chips.

#### **Unit 5: Techniques in Biochemistry**

Principles of optical, phase contrast, fluorescence and electron microscopy, spectrophotometry, UV and VIS, fluorimetry, turbidometry and atomic absorption spectrophotometry. Radioisotopic techniques – scintillation counters and autoradiography and their application in biological sciences. Electrophoresis - general principles and application, gel electrophoresis, isoelectric focusing, pulsed field gel electrophoresis, immunoelectrophoresis. Chromatographic techniques - paper, thin layer, column chromatography, GC and HPLC. Centrifugation - principles of sedimentation in various rotors, differential centrifugation, density gradient centrifugation and ultracentrifugation. Cell tissue and organ culture. Cryopreservation, PCR and application of RFLP, RAPD, AFLP, microsatellite and mitochondrial and ribotyping techniques. Southern, Northern and Western blotting, ELISA. Microarray and DNA chips. Preliminary methods of statistical analysis as applied to agricultural data – standard deviation, standard error, ANOVA, correlation and regression.

#### **Unit 6: Biochemistry of Food-grains, Fruits and Vegetables**

Fundamentals of nutrition, concept of balanced diet. Nutritional quality of protein and its evaluation. Dietary fibre. Vitamins- biochemical functions and deficiency diseases. Fats and lipids-types of fatty acids and their significance in health. Biochemical composition and food value of various food grains (including cereals, pulses, oil seeds), fruits and vegetables. Biochemistry of fruit ripening, biochemical aspects of post harvest technology, storage and preservation. Biochemical basis of quality improvement of food grains, vegetables and fruits. Antioxidants, nutraceuticals. Food toxins and anti-metabolites, food additives, storage proteins.

#### **Unit 7: Photosynthesis**

Photosynthesis – photosynthetic pigments, light reactions, photosystems. Photophosphorylation, dark reactions: C3, C4 and CAM pathways. Regulation of Rubisco. Chemiosmotic coupling. Carbon cycle and its regulation, Ion fluxes and conformational changes during photosynthesis. Photorespiration. Relationship between photosynthesis, photorespiration and crop productivity. Chloroplast morphology, structure and biochemical anatomy. Cytosolic and organelle interactions. Nature and exchange of metabolites through translocators. Seed reserve biosynthesis.

#### **Unit 8: Plant Metabolic Processes**

Uptake and metabolism of mineral nutrients in plants. Sulphur metabolism. Nitrogen cycle, nitrate and nitrite reduction, denitrification, symbiotic and non-symbiotic nitrogen fixation. Biochemical and physiological role of hydrogenase. Chemoautotrophy in rhizobia and nitrifying bacteria. Cell cycle. Growth regulation in plants. Signal transduction and phytohormones. Molecular mechanisms of plant growth, hormone action. Role of oligosaccharides and polysaccharides in cellular metabolism. Metabolism of cyanogenic glycosides and glucosinolates.

#### **Unit 9: Plant Molecular Biology**

General organization of nuclear, mitochondrial and chloroplast genomes. Genomics and functional genomics. Tissue specific expression of genes. Molecular biology of various stresses – drought, salinity and temperature. Signal transduction and its molecular basis: molecular mechanism of plant hormone action. Structure, organization and regulation of nuclear genes. Genes involved in photosynthesis and



nitrogen fixation. Regulation of chloroplast gene expression. Mitochondrial control of fertility. Molecular markers in plants and their uses.

#### **Unit 10: Plant Biotechnology / Genetic Engineering**

Totipotency, application of tissue culture for plant improvement, cryopreservation. Protoplast fusion. General principles of gene cloning. Isolation and characterization of plant genes and promoters. Different methods of gene transfer –direct and vectormediated. Gene silencing. Site directed mutagenesis. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement – insect-pest resistance (insect, viral, fungal and bacterial diseases). Abiotic stress tolerance, herbicide resistance, storage protein quality improvement, increasing shelf- life, oil quality. Biosafety and IPR issues.



## **08. PLANT PATHOLOGY**

### **Unit 1: History and Principles of Plant Pathology**

Milestones in phytopathology with particular reference to India. Major epidemics and their social impacts. Historical developments of chemicals, legislative, cultural and biological protection measures including classification of plant diseases. Physiologic specialization, Koch's postulates. Growth, reproduction, survival and dispersal of plant pathogens. Factors influencing infection, colonization and development of symptoms.

### **Unit 2: Laboratory and Analytical Techniques**

Preparation and sterilization of common media. Methods of isolation of pathogens and their identification. Preservation of microorganisms in pure culture. Methods of inoculation. Measurement of plant disease. Molecular detection of pathogens in seeds and other planting materials: Nucleic acid probes, Southern, Northern and Western hybridization, ELISA, ISEM and PCR. Laboratory equipment and their use: autoclave, hot air oven, laminar flow, spectrophotometer, electrophoresis, light and electron microscopy, incubator, ultracentrifuge, ELISA Reader.

### **Unit 3: Physiological and Molecular Plant Pathology**

Altered metabolism of plants under biotic and abiotic stresses. Molecular mechanisms of pathogenesis: recognition phenomenon, penetration, invasion, primary disease determinant. Enzymes and toxins in relation to plant disease. Mechanisms of resistance. Phytoalexins. PR proteins. Antiviral proteins. SAR. HR and active oxygen radicals. Tissue culture. Somoclonal variation and somatic hybridization. Elementary genetic engineering. Management of pathogens through satellite, antisense - RNA. Ribozymes, coat protein, hypovirulence cross protection/useful genes and promoter technology biosafety and bioethics.

### **Unit 4: Mycology**

Classification of fungi. Economic mycology, edible fungi and entomogenous fungi. Mycorrhizal associations. Cell organelles, their morphology, functions and chemical composition.

### **Unit 5: Plant Bacteriology**

Identification and classification of bacteria. morphology, ultrastructure and chemical composition of prokaryotic cell in relation to function. Growth curve, nutrition and auxotrophic mutants. Resting cells in prokaryotic, elementary bacterial genetics and variability: transformation, conjugation, transduction. Biology of extra chromosomal elements: plasmid borne genes and their expression: *avr*, *her*, *vie* and *pat* genes. Bacteriophages: lytic and lysogenic cycles. Prokaryotic inhibitors and their mode of action. Economic uses of prokaryotes. Morphology, biochemical characteristics, reproduction and life cycle of phytoplasma and other fastidious prokaryotes.

### **Unit 6: Plant Virology**

Nature, composition and architecture of viruses and viroids. Properties of viruses. Variability in viruses. Satellite viruses and satellite RNA. Assay of plant viruses including biological, physical, chemical, serological and molecular methods. Conventional and biotechnological techniques used in detection and diagnosis. Behaviour of viruses in plants including infection, replication and movement. Histopathological changes induced by viruses in plants, inclusion bodies. Transmission of viruses: virus - vector relationships. Nomenclature and classification of viruses.

### **Unit 7: Plant Disease Epidemiology**

Concepts in epidemiology. Development of disease in plant population. Monocyclic and polycyclic pathogens. Role of environment and meteorological factors in the development of plant disease epidemics. Survey, surveillance (including through



remote sensing), and prediction and forecasting of diseases. Epidemic analysis and prediction models. Crop loss assessment: critical and multiple point models.

#### **Unit 8: Phanerogamic parasites and Non-parasitic Diseases**

Diseases caused by Phanerogamic parasites and their management. Diseases due to unfavourable soil environment, drought and flooding stress etc. Nutritional deficiencies. Primary /secondary air pollutants and acid rain.

#### **Unit 9: Fungal Diseases of Crop Plants**

Fungal diseases of cereals, millets, oilseeds, pulses, fruits, vegetables, plantation, fiber, spices and ornamental crops with special reference to etiology, disease cycle, perpetuation, epidemiology and management. Post harvest diseases in transit and storage; aflatoxins and their integrated management.

#### **Unit 10: Bacterial and Viral Diseases of Crop Plants**

Crop diseases of cereals, pulses, oilseeds, vegetables, fruits, plantation and fiber crops caused by bacteria, viruses, viroids, phytoplasmas and other fastidious prokaryotes. Mode of transmission and pathogen vector relationships. Epidemiology and management.

#### **Unit 11: Management of Plant diseases**

General principles of plant quarantine. Exotic pathogens and pathogens introduced into India. Sanitary and phytosanitary issues under WTO, TRIPS and PRA. Genetic basis of disease resistance and pathogenicity: gene for gene hypothesis; parasite mediated frequency -dependent selection concept of QTL mapping; breeding for disease resistance. Production of disease free seeds and planting materials. Seed certification. Chemical nature and classification of fungicides and antibiotics: their bioassay and compatibility with other agricultural chemicals; resistance to fungicides/ antibiotics; effect on environment. Spraying and dusting equipments, their care and maintenances. Important cultural practices and their role in disease management, solarization, integrated disease management. Microorganisms antagonistic to plant pathogens in soil, rhizosphere and phyllosphere and their use in the control of plant diseases; soil fungistasis. Plant growth promoting Rhizobacteria.



## **09. PLANT PHYSIOLOGY**

### **Unit 1: Cell Organelles and Water Relations**

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, 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, plant factors influencing transpiration rate. Stomata, structure function - Mechanism of stomatal movement, antitranspirants. Physiology of water high temperature and salinity stress in plants. Influence of water stresses at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

### **Unit 2: Metabolic Processes and growth Regulation**

Energy and work, free energy and chemical potential, redox reactions and electrochemical potential. Enzyme classification and mechanism of action, factors affecting enzyme action. Gene expression and protein turnover. Photosynthesis, translocation and respiration as key processes regulating carbon metabolism and plant growth. Photosynthesis and bioproductivity. Photochemical process-Chloroplast, its structure, CAM plants and their significance. Rubisco structure and regulations, Photorespiration and its significance, CO<sub>2</sub> fixation as a diffusive process, effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides. Translocations 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 (N<sub>2</sub>, NO<sub>3</sub>, NH<sub>3</sub>) and their reduction, protein synthesis, nucleic acids. Sulphate uptake and reduction. Lipid metabolism- storage, protective and structural 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 and their metabolism, synthetic growth regulators, growth retardant, apical dominance, senescence, fruit growth, abscission, photomorphogenesis, photo-receptors, phytochrome, physiology of flowering, photoperiodism and vernalisation.

### **Unit 3: Crop Productivity and Modeling**

Role of crop physiology in agriculture, crop growth and productivity, crop growth models describing yield (Duncan/Passioura), phenology-crop productivity, growth factors related to biomass - concept of growth rates- canopy photosynthesis (leaf area and net assimilation rates as determining factors). Light interception as a major function of leaf area-index, LAD canopy architecture- Light extinction coefficient relative growth rate. Net assimilation rate. Biomass and yield relations. Assimilate partitioning, 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. Ideotype concept-selection- indices for improving crop productivity.

### **Unit 4: Abiotic Stress Responses in Plants**

Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, interactions between biotic and abiotic stresses. Drought 21 characteristic features, water potential in the soil-plant-air continuum. Development of water deficits, energy balance concept, transpiration and its regulation – stomatal



functions/VPD. Physiological process 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 function genes and significance of gene products. Stress and hormones-ABA as a signaling molecule – Cytokinin as 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 temperature tolerance. Functions of HSPs 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. Breeding for salt resistance. Heavy metal stress: aluminum and cadmium toxicity in acid soils. Role of phytochelatins (heavy, metal binding proteins).

#### **Unit 5: Plant Growth Regulators and Plant Development**

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 influence on plant growth and development by auxins, gibberellins, cytokinins, abscisic acid and ethylene. Concept of hormone action - hormone receptors and signal transduction Hormone mutants. 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. 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. Synthetic growth regulators, growth retardants, apical dominance, senescence, fruit growth, abscission. Growth and differentiation, hormonal concept of growth and differentiations. Rooting of cuttings- flowering- physiological and molecular aspects of control of reproductive growth. Apical dominance, senescence and abscission. Fruit growth and development, physiological and molecular aspects of ripening processes and improving post harvest life of fruits. Induction and breaking dormancy in seeds and buds. Synthetic growth regulators. Practical utility in agriculture and horticulture. Herbicides, classification and their mode of action.

#### **Unit 6: Mineral Nutrition**

Importance of mineral nutrition in plant growth. Classification and essentiality criteria. General mechanisms - concept of apparent free space and nature of biomembranes. Dual mechanism and other concepts of ion uptake. Short distance transport-pathway from external solution (Apoplast) to sieve 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. 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. Interaction of phytohormones and nutrients. Molecular aspects- uptake and transport, role of transporter genes, genetics of nutrient uptake, identification and transfer of genes for tolerance to nutrient deficiencies, etc.



### **Unit 7: Climate and Climate Change**

Climate- Analytical methods to determine long term changes in environment- Tree ring, cellulose, stable carbon isotope discrimination, stable  $^{18}\text{O}$  discrimination for hydrological changes. Likely changes in climate in future and its impact on crop and ecosystems. The greenhouse gases and global warming.  $\text{CO}_2$  as an important greenhouse gas, global carbon deposits, fluxes in the sinks and sources. Approaches to contain atmospheric  $\text{CO}_2$  level. Effect of elevated  $\text{CO}_2$  on plant growth and development. Methane as a greenhouse gas. Prediction on global warming, GCM models, effects on climate and biota. High temperature and  $\text{CO}_2$  interaction on plant growth and productivity, ionising radiation UV-B chlorofluoro carbon (CFC)- their impact on ozone layer- ozone hole and alteration in UV-B radiation. Effects of UV-B radiation on plant ecosystem, repair and acclimation to UV-B damage. Carotenoids and their role in membrane stabilization. Air pollution,  $\text{SO}_2$ ,  $\text{NO}$ , methane, ozone, peroxy acetyl nitrate and their effect on ecosystem. Industrial and domestic effluent- their effect, on aquatic ecosystem, plant growth and development.

### **Unit 8: Seed Physiology**

Structure of seeds and their storage. Seed development 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. 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 reserves. Role of embryonic axes. Gibberellin and  $\alpha$ -amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, role of LEA proteins. Seed viability. Seed dormancy. Means to overcome seed dormancy.

### **Unit 9: Physiology of Flowering and Reproduction**

Evolutionary history of flowering plants (angiosperms). Semelparous and iteroparous reproduction, monocarpic and perennial life 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 flowering. Endogenous substances and flowering. Gene expression in flowering. Control of flowering. Thermoperiodism - photo and thermo-period interactions. Vernalization-mechanism. Photomorphogenesis, photoreceptors, phytochrome, cryptochrome, physiology of flowering, photoperiodism and vernalization. Optimization in flowering response-to environmental features (light, temperature, stress) etc. plant reproductive physiology. Mating strategy in plants, molecular techniques to understand mating patterns, self-incompatibility responses, physiological processes mediating fertilization (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.

### **Unit 10: Physiology of Horticultural and Plantation Crop species**

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 rate and water use efficiency. Sexual and asexual propagation. Rootstock 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 aspects of plantation crops: tea, coffee, cardamom, coconut, and blackpepper.

#### **Unit 11: Post-Harvest Physiology**

Senescence and ageing in plants. Ethylene – the senescence hormone, leaf senescence. Monocarpic plant senescence. Biochemistry and molecular biology of flower senescence. Gene expression during senescence. Concept of physiological maturity of seeds - post harvest changes in biochemical constituents in field crops - loss of viability, loss of nutritive value, environmental factors influencing post-harvest deterioration of seeds. Physiological and biochemical changes during fruit ripening and storage. Senescence and post harvest life of cut flowers. Physical, physiological and chemical control of post - harvest deterioration of fruits, vegetables and cut flowers and its significance during storage and transport. Molecular approach in regulation of fruit ripening. Transgenic technology for improvement of shelf-life. Edible vaccine

#### **Unit 12: Morphogenesis, Tissue Culture and Plant Transformation**

Morphogenesis; the cellular basis of growth and morphogenesis; polarity in tip growing cells and diffusive growing cells. Control of cell division and differentiation, phytochromes, different forms, physiological effects and gene regulation, and cellular totipotency, physiology and biochemistry of differentiation, in organ cell, tissue and cultures, micropropagation strategies, application of tissue culture in agriculture, horticulture, forestry and industry: plant transformation; transformation vectors, concept of selectable and scorable markers. *Agrobacterium* mediated transformation, binary vectors, biolistics. Electroporation, selection of putative transgenic plants, genetic analysis. PCR, Southern analysis evaluation of transgenic plants.



## **10. SEED SCIENCE AND TECHNOLOGY**

### **Unit 1 : Seed Biology**

Floral biology, mode of reproduction, sporogenesis, pollination, fertilization, embryogenesis, fruit and seed development. Apomixis, parthenocarpy, polyembryony and somatic embryoids and synthetic seeds. Seed structure of monocot and dicot. Seed maturation and longevity in orthodox and recalcitrant seed. Chemical composition of seed. Seed dormancy - types, causes and mechanisms of induction and release, factors affecting, methods to overcome dormancy and its significance in agriculture. Seed germination - requirements, imbibition pattern, physiological and biochemical changes, and role of hormones.

### **Unit 2 : Seed Production**

Introduction to crop breeding methods. Variety testing, release and notification. Genetic purity concept and factors responsible for deterioration of varieties. Maintenance breeding. General system of seed multiplication. Seed production agencies. Identification of seed production areas and factors affecting it. Compact area approach in seed production. Seed production planning, equipment, input and manpower requirement. Factors affecting pollination and seed set viz., temperature, humidity, wind velocity, insect pollinators, and supplementary pollination. Male sterility, self-incompatibility and their role in hybrid seed production. Principles and methods of seed production of varieties and hybrids of cereals like wheat, paddy, sorghum, pearl millet and maize; pulses like chickpea, pigeon pea, green gram, black gram, soybean and cowpea; oilseeds like groundnut, brassica, sesame, sunflower and castor; fibre crops like cotton and jute; vegetables crops like tomato, brinjal, okra, chilli, important cole and cucurbitaceous crops; important forage legumes and grasses and seed crop management, time of harvesting and threshing/extraction methods. Seed production technology of plantation crops like coffee, tea, rubber, cocoa, cardamom and pepper. Disease free clonal propagation of crops like potato, sugarcane sweet potato, tapioca, colocasia, betel vine, fruit crops like mango, citrus, banana, guava, sapota, pineapple, grape, apple, pear, plum, peach, apricot and seed production and clonal propagation of annual and perennial flowers like rose, gladiolus, chrysanthemum, marigold, dahlia, phlox and petunia. Clonal standards and degenerations. Micro propagation.

### **Unit 3 : Seed Processing**

Principles of seed processing. Seed drying principles and methods. Precleaning, grading, treatment, pelleting and packaging. Seed invigoration and enhancement treatment and their applications. Seed processing machines like cleaner cum grader, specific gravity separator, indented cylinder, seed treater, weighing and bagging machines, their operation and maintenance. Seed quality maintenance during processing.

### **Unit 4: Seed Quality Control**

Seed legislation - Seeds Act 1966, Seed Rules 1969 and New Seed Bill 2004, Seed Law Enforcement. Seed certification - history, concept, organization, phases and minimum certification standards. Field inspection principles and methods. Inspection at harvesting, threshing and processing. Pre-and post quality testing or genetic purity. Seed Certification Schemes, concepts and procedures. Seed Testing concepts and objectives, its role in seed quality control. Seed sampling, seed moisture testing, purity analysis, germination testing, tolerance tests and equipment. Seed testing



procedures for principal agri horticultural crops. Quick viability tests. Seed vigour, its significance and testing methods. Testing for genuineness of varieties – principles and methods based on seed, seedling and plant characters, biochemical techniques namely electrophoresis of proteins and isoenzymes and DNA fingerprinting. International Seed Testing Association (ISTA), its role in development of seed testing procedures, rules and seed quality assurance for international seed trade.

#### **Unit 5 : Seed Storage**

Requirements and types of seed storage. Factors affecting seed storage and role of moisture, temperature, RH and moisture equilibrium. Viability nomographs. Seed deterioration causes and methods of control. Physiological, biochemical and molecular changes in seed ageing. Seed drying and Packaging needs. Storage structures. Methods of stacking and their impact. Short and medium term storage. Controlled storage. Germplasm storage. Cryo preservation. Design features of short, medium and long-term seed storage buildings. Operation and management of seed stores.

#### **Unit 6 : Seed Health**

Significance of seed health. Mode and mechanism of transmission of microorganisms - fungi, bacteria and viruses. Procedures for seed health test and rules. Externally and internally seed - borne pathogens, mode of infection, development and spread, methods of detection of seed borne diseases. Important seed-borne diseases of cereals, oilseeds, pulses, fibre crops, vegetables and their control measures. Quarantine and International procedures of phytosanitary certificates. Important storage pests, their identification, monitoring and detection. ET value, nature and extent of damage, natural enemies and management. Use of pesticides, botanicals, mycotoxins for seed treatments. Carry over infestation, principles of fumigation and safe use of fumigants.

#### **Unit 7: Seed Industry Development and Marketing**

Trends in National and International seed industry development. International Seed Trade Federation (ISF) and Indian seed associations. Economics of seed production. Market survey, demand forecasting, pricing policies, marketing channels, planning and sales promotion. Buyer behavior and role of Government, semi Government, co-operative and private sectors in seed trade. Responsibilities of seed companies and dealers in Seed Act. Seed import and export.

#### **Unit 8 : Protection of Plant Varieties**

Plant Variety Protection (PVP) and its significance. Protection of Plant Varieties and Farmers' Right Act, 2001, its essential features. International Union for the Protection of New Varieties of Plants (UPOV) and its role in development of Plant breeders Rights and Seed Industry Development. Impact of PVP on seed supply system. DUS testing principles and application. Biodiversity Act. Criteria for protection of Essentially Derived Varieties (EDVs) and Genetically modified (GM) varieties.