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<tr>
<td>*PP.501</td>
<td>PRINCIPLES OF PLANT PHYSIOLOGY- I : CELL ORGANELLES, WATER RELATIONS AND MINERAL NUTRITION</td>
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<tr>
<td>*PP.502</td>
<td>PRINCIPLES OF PLANT PHYSIOLOGY- II: METABOLIC PROCESSES AND GROWTH REGULATION</td>
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<td>*PP.503</td>
<td>PLANT DEVELOPMENTAL BIOLOGY – PHYSIOLOGICAL AND MOLECULAR BASIS</td>
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<td>*PP.504</td>
<td>PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES</td>
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<td>*PP.505</td>
<td>HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT</td>
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<td>*PP.506</td>
<td>PHYSIOLOGY OF GROWTH, YIELD AND MODELING</td>
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<td>PP.507</td>
<td>GENOME ORGANIZATION IN HIGHER PLANTS</td>
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<td>*PP.508</td>
<td>MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION</td>
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<td>PP.509</td>
<td>PHYSIOLOGY OF CROP PLANTS – SPECIFIC CASE STUDIES</td>
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<td>PP.510</td>
<td>PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS – CARBON AND NITROGEN</td>
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<td>MINERAL NUTRITION</td>
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<td>MASTER'S RESEARCH</td>
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<td>**PP.601</td>
<td>FUNCTIONAL GENOMICS AND GENES ASSOCIATED WITH A FEW PHYSIOLOGICAL PROCESSES</td>
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<td>**PP.602</td>
<td>SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES</td>
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<td>**PP.603</td>
<td>MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS</td>
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<td>PP.604</td>
<td>TECHNIQUES IN PLANT PHYSIOLOGY</td>
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<td>PP.605</td>
<td>CLIMATE CHANGE AND CROP GROWTH</td>
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<td>PP.606</td>
<td>POST-HARVEST PHYSIOLOGY</td>
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<td>PP.607</td>
<td>WEED PHYSIOLOGY AND HERBICIDE ACTION</td>
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<td>PP.608</td>
<td>SEED PHYSIOLOGY</td>
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<td>DOCTORAL RESEARCH</td>
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*Compulsory for Master's programme; ** Compulsory for Ph. D. programme

**Minor Departments**  
Biochemistry  
Genetics & Plant Breeding  
Plant Molecular Biology and Biotechnology

**Supporting Departments**  
Statistics and Mathematics  
Microbiology  
Agronomy  
Computer Science.

**Non credit compulsory courses**

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<td>TECHNICAL WRITING AND COMMUNICATION SKILLS</td>
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<td>INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE</td>
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<td>PGS 504</td>
<td>BASIC CONCEPTS IN LABORATORY TECHNIQUES</td>
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<td>AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES</td>
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<td>PGS 506</td>
<td>DISASTER MANAGEMENT</td>
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*Compulsory for Master's programme; ** Compulsory for Ph. D. programme
Objective
To impart the students with basic knowledge of cell physiology and plant nutrition with relevance to agriculture

Theory

UNIT I
Plant cell: structure & function – cell theory, cell organelles, structure and physiological functions of cell wall

UNIT II
Cell membranes, fluid mosaic model, importance of membranes in cell organelles, role of plasmodesmata

UNIT III
Endoplasmic reticulum - golgi apparatus – role in metabolism – diverse function in cell cycle and development, Exocystosis and endocystosis – membrane compartments associated with recycling

UNIT IV
Vacuoles, role of multifunctional compartments - Nucleus , nuclear pore and nucleolus – organization and role in cell functioning

UNIT V
Plastids - Mitochondria - peroxisomes – organization and role in cell functioning

UNIT VI

UNIT VII
Transpiration – significance – factors affecting transpiration – stomata, structure, function and regulation – WUE and factors affecting WUE – Anti-transpirants

UNIT VIII
Physiological aspects of water deficit – influence at cell, organ and canopy level – indices of drought resistance in plants - Transpiration efficiency – intrinsic WUE – scope for plant improvement and crop yield

UNIT IX
Plant nutrition – Role of nutrients in plant metabolism – Criteria of essentiality – classification of plant nutrients

UNIT X
Mechanism of uptake and transport - Role of membranes in nutrient transport - Symplast
and apoplast – carrier concept – phloem mobility –

**UNIT XI**
Factors influencing the availability and uptake of plant nutrients - Role of mycorrhiza and root exudates in plant nutrition

**UNIT XII**
Physiological role of plant nutrients – N, P, K, Ca, Mg, S, Fe, Cu, Mn, Zn, Mo, B, Cl, Na and Si

**UNIT XIII**
Plant nutritional disorders – Deficiency and toxicity symptoms in crop plants, reasons and remedial measures ;

**UNIT XIV**
Foliar nutrition – uptake and transport – Factors influencing foliar uptake of nutrients – significance

**Practical**

**Suggested Readings**

**PP 502**
**PRINCIPLES OF PLANT PHYSIOLOGY - II :**
**2+1**
**METABOLIC PROCESSES AND GROWTH REGULATION**

**Objectives**
To acquaint the students with the basic concepts of physiological process and their relationship with growth regulation
Theory

UNIT I
Introduction – Photosynthesis, translocation and respiration as key processes regulating carbon metabolism and plant growth

UNIT II
Photosynthesis and its importance in bioproductivity – Photosynthetic apparatus – chloroplast and its structure Photochemical reactions – Absorption of light – Fate of excited chlorophyll – Electron and photon transport and bioenergetics

UNIT III

UNIT IV

UNIT V
Synthesis of sucrose, starch, oligo and polysaccherides from triose phosphate generated by the C₃ cycle.

UNIT VI
Translocation of photosynthesis – Apoplastic and symplastic path way – short distance and long distance transport – phloem loading and unloading . Importance of translocation in sink growth.

UNIT VII

UNIT VIII
TCA cycle and HMP pathway – respiration chain (ETS) – Carbon balance – factors influencing respiration- Growth and maintenance respiration, cyanide resistant respiration and its significance

UNIT IX
Nitrogen metabolism; inorganic nitrogen species (N₂, NO₃ and NH₃) and other reduction to amino acids – biological N fixation. Protein synthesis : The components of protein synthesis. The mechanism of protein synthesis and regulation of protein synthesis.

UNIT X
Nucleic acid synthesis – Activation of nucleic acid (DNA & RNA) precursors – splitting of high energy pyrophosphate group – Union of nucleoside monophosphate group

UNIT XI
Lipid metabolism : storage, protective and structural lipids – Their composition and functions- Biosynthesis of fatty acids, diacylglycerol and triacyl glycerol.
UNIT XII
Secondary metabolites (Terpenes, Phenolic compounds and N containing compounds) and their role in plant defense mechanism

UNIT XIII
Growth and differentiation: Hormonal concept of growth and differentiation - Auxins and gibberellins, Cytokinins, ABA and Ethylene - Biosynthesis and Physiological roles - growth regulators and growth retardants, Apical dominance, senescence, fruit growth and abscission

UNIT XIV
Photomorphogenesis and Phytochrome – Phytochrome regulation of morphogenesis – Different types of phytochrome and its biochemical properties.

UNIT XV

Practical
Radiation energy measurements, Separation and quantification of chlorophylls, Measurement oxygen evolution during photosynthesis, Measurement of respiration rates, Measurement of gas exchange parameters, conductance and photosynthetic rate, Measurement of photorespiration, Estimation of reducing sugars, Estimation of starch, Estimation of Nitrates in the xylem exudates, Estimation of amino acids in the xylem exudates, Quantification of soluble proteins, Bioassays for Auxins & Gibberellins, Bioassays for Cytokinins, Bioassays for ABA, Bioassays for Ethylene, Photoperiodic responses of plants in terms of flowering

Suggested Readings
Objective
To explain about basic physiological and molecular processes concerning various facets of growth and development of plants.

Theory

UNIT I
Plant Biodiversity, Concept of evolution in plants.

UNIT II
General Aspects - Novel features of plant growth and development; Concept of plasticity in plant development; Analysing plant growth

UNIT III
Seed Germination and Seedling Growth - MObilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth.

UNIT IV
Shoot, Leaf and Root Development - Organization of shoot apical meristem(SAM); Control of cell division and cell to cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of root apical meristem(RAM); Root hair and trichome development; Cell fate and lineages.

UNIT V
Floral Induction and Development - Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation; Sex determination.

UNIT VI
Seed Development and Dormancy - Embryo and endosperm development; Cell lineages during late embryo development; Molecular and genetic determinants; Seed maturation and dormancy.

UNIT VII
Senescence and Programmed Cell Death (PCD) - Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

UNIT VIII
Light Control of Plant Development - Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants.

UNIT IX
Embryonic Pattern Formation - Maternal gene effects; Zygotic gene effects; Hometic gene effects in Drosophila; Embryogenesis and early pattern formation in plants.
UNIT X
Regeneration and totipotency; Organ differentiation and development; Cell lineages and developmental control genes in maize.

UNIT XI
Special Aspects of Plant Development and Differentiation - Pollen germination and pollen tube guidance; Phloem differentiation; Sex determination in plants;

UNIT XII
Self - incompatibility and its genetic control; Heterosis and apomixis.

Suggested Readings
Kabita Datta 2007, Plant Physiology, Mittal Publ.

PP 504 PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES

Objective
To apprise the students regarding abiotic stress to plant and its molecular basis.

Theory
UNIT I
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.

UNIT II

UNIT III
Transpiration and its regulation - stomatal functions

UNIT IV
Physiological processes affected by drought, Drought resistance mechanisms: Escape Dehydration postponement (Drought avoidance), Dehydration tolerance and characteristics of resurrectionn plants. Osmotic adjustment, Osmoprotectants, Stress proteins. Water use efficiency as a drought resistant trait.

UNIT V
Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products.
UNIT VI
Stress and hormones - ABA as a signaling molecule - Cytokinin as a negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD catalase etc.)

UNIT VII
High temperature stress: Tolerance mechanisms - role of membrane lipids in high temperature tolerance. Functions of HSP’s.

UNIT VIII

UNIT IX
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.

UNIT X
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 behavior, Heat tolerance and membrane integrity. Sullivans 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 techniques for chilling tolerance.

Suggested Readings

PP 505 HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT 2+1

Objective
To apprise the students about structure function of plant growth regulator on growth and development of plant.

Theory
UNIT I
Definition and classification of plant growth regulators - Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones, tricontanol, Phenols - polyamines, jasmonates, concept of death hormone.
UNIT II
Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones - Auxins, Gibberlins, cytokinins, Abscisic acid and Ethylene Brassinosteroids.

UNIT III
Hormone mutants and transgenic plants in understanding role of hormones.

UNIT IV
Signal perception, transduction and effect at functional gene level of different hormones - Auxins - cell elongation, Gibberellins - 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.

UNIT V

UNIT VI
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 rooting of cuttings, abscission, apical dominance, Gibberellins - bioassays - GA effect on germination of dormant seeds, cytokinin- bioassays - estimation using immunoassay technique cytokinin effect on apical dormance and senescence, ABA bioassays estimation using immunoassay technique. ABA effect on somatal movement, Ethylene bioassays, estimation using physico chemical techniques - effect on breaking dormancy in sunflower and groundnut.

Suggested Readings

UNIT I
Crop growth analysis, key growth parameters. Analysis of factors limiting crop growth and productivity - the concept of rate limitation.
UNIT II
Phenology- Growth stages, internal and external factors influencing flowering. Photoperiodic and thermo-periodic responses and the concept of Degree days and crop growth duration.

UNIT III
Canopy architecture, light interception, energy use efficiency of different canopies. LAI, LAD. concept of optimum LAI.

UNIT IV
Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity – partitioning efficiency and harvest index.

UNIT V
Plant growth analysis techniques, yield structure analysis, theoretical and actual yields.

UNIT VI
Plant ideotypes,

UNIT VII
Simple physiological yield models- Duncan’s. Monteith’s, and Passioura’s

UNIT VIII
Crop growth models-empirical models testing and yield prediction.

Practical
Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA portioning efficiency HI, Measurement of light interception, light extinction coefficient, Energy utilization efficiency based energy intercepted, and realized, Computer applications in plant physiology, Crop productivity and modeling.

Suggested Readings
Hunt R. *Plant Growth Curve - The Fundamental Approach to Plant Growth Analysis*. Edward Arnold.
Objective
To impart basic concept on genome organization in prokaryotic and eukaryotic system.

Theory

UNIT I
Introduction: Basic discoveries in molecular genetics; basic concepts on genome organization and its replication in prokaryotic systems including cyanobacteria; genome organization in diploids, tetraploids, autotetraploids and polyploids.

UNIT II
Gene & gene expression: Diversity in DNA polymerases; control of plasmid copy number; Regulation of transcription in prokaryotes; Promoters and terminators; Positive and negative control of transcription; Repression and activation-operon concept.

UNIT III
Mitochondrial and chloroplastic genome organization and regulation of gene expression.

UNIT IV
Eukaryotic genome structure: Organization and replication; control of gene expression-transcription and post-transcriptional; promoter analysis; concept of cis elements; transcription factors, function and role of RNA polymerases.

UNIT V
Genetic code and translation-deciphering the genetic code; Codon bias; tRNAs, ribosomes; Initiation and termination of translation; Translational and post-translational controls; Attenuation; Suppressor tRNAs.

UNIT IV
Mobile genetic elements; Structure and function of transposable elements; Mechanism of transposition; Special features of retrotransposans; Repair and recombination.

Practical
Culturing and transformation of bacteria; genomic DNA and plasmid DNA isolation from bacteria, restriction enzyme digestion and analysis by agarose gel electrophoresis, isolation of genomic DNA and RNA from plants and quantification; Culture of bacteriophage; studies on lytic and lysogenic phages.

Suggested Readings
Theory

UNIT I
Morphogenesis: The cellular basis of growth and morphogenesis cytodifferentiation.

UNIT II
The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and cellular totipotency.

UNIT III
Introduction to in vitro methods: Terms and definitions, Use of growth regulators, Beginning of in vitro cultures in our country (ovary and ovule culture, in vitro pollination and fertilization), Embryo culture, embryo rescue after wide hybridization and its application, Endosperm culture and production of triploids.

UNIT IV

UNIT V

UNIT VI
Use of plant cells, protoplast and tissue culture for genetic manipulation of plant: Introduction to A. tumefaciens. Tumour formation on plants using A. tumefaciens (Monocots vs Dicots), Root – formation using A. rhizogenes

Practical
In vitro culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes; Effect of explant age on propagation potential, Effect of growth regulators auxin, cytokinins and ethylene on callus induction, organogenesis; Somatic embryogenesis, Effect of growth conditions such as temperature and photoperiod on organogenesis, Single – cell suspension cultures.

Suggested Readings

PP 509 PHYSIOLOGY OF CROP PLANTS – SPECIFIC 2+0 CASE STUDIES

Objective
To impart knowledge of physiological aspects of different crop plants.
Theory

UNIT I
Crop physiological aspects of rice, wheat, maize, sorghum, millets, sugarcane, pulses, oil seeds, cotton and potato Crops. Six to Eight Species could be chosen based on local importance.

UNIT II
Crop specific topics.

UNIT III
Seed dormancy, photoperiodic and thermoperiodic responses.

UNIT IV
Source-sink relationship, Yield structure and factors influencing yield, Nutrients and other resource requirements and crop specific features.

Suggested Readings
Pessarakli M. Handbook of Plant and Crop Physiology. CRC Press.
Selected reviews and articles from Periodicals and Journals.

Objective
To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation.

Theory

UNIT I
Photosynthesis- its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere.

UNIT II
Physiological and biochemical aspects: chloroplast structure development and replication, ultra structure of thylakoids, photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, and concept of quantum yield.

UNIT III
Photosynthetic carbon reduction cycle and its regulation. CO2Concentration Mechanism (CCM) as a complementary strategy for carbon fixation. CCM in photosynthetic bacteria, micro algae, Submerged Aquatic macrophages (SAM), C4, CAM and single celled C4 organisms, C3-C4 intermediates. Ecological significance of CCM.

UNIT IV
Rubisco structure, assembly and kinetics, photorespiration and its significance.
UNIT V
Carbon fluxes between chloroplast and cytoplasm and Carbon fixation as a diffusive process, the concept of ra, rs and rm. Pi recycling, starch and sucrose synthesis and export. Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress VPD etc.

UNIT VI

UNIT VII

UNIT VIII
Prospects of improving photo synthetic rate and productivity – potential traits of photosynthesis- biotechnological approaches.

UNIT IX
Nitrogen assimilation in photosynthesizing cells – NO3-, NO2 - reduction, GS-GOGAT pathway. Photorespiration loss of Ammonia and its reassimilation and NUE.

Practical

Suggested Readings

MINERAL NUTRITION

PP 511

Objective
To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation
Theory

UNIT I
Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological actions influencing nutrient availability near the root system.

UNIT II
Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity.

UNIT III
Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients. Multiple transporters for a single ion and their functional regulation.

UNIT IV
Molecular physiology of micronutrient acquisition. Examples of genes encoding mineral ion transporters. Strategies plants adopt to acquire and transport minerals under deficient levels.

UNIT V
Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, Examples of Phosphorous, Iron and Zinc efficient crop varieties.

UNIT VI
Breeding crop varieties for improved nutrient efficiency. Plant responses to mineral toxicity.

Practical
Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels. Quantification of pigment levels, enzyme activities.

Suggested Readings
Press.

PP 601 FUNCTIONAL GENOMICS AND GENES
ASSOCIATED WITH A FEW PHYSIOLOGICAL PROCESSES
2+0

Objective
To impart knowledge about physiological process of plant at molecular level.

Theory

UNIT I
UNIT II
Genetic tools for plant development- Understanding the importance of mutants in unraveling the physiological processes – T-DNA insertion mutants, Gain in function, Transposon mutagens, Transposition, Physical and Chemical mutagenesis, Gene and Enhancer Traps for Gene Discovery, High-Throughput TAIL-PCR as a Tool to identify DNA Flanking insertions, High-Throughput TILLING for functional Genomics.

UNIT III
Gene knock out approaches: Antisense technology, Virus induced gene silencing (VIGS), Custom Knock-outs with Haripin RNA-mediated Gene Silencing and other silencing tools, Complementation studies, DNA micro arrays.

UNIT IV
Gene Over expression approaches: Vector Construction for Gene Overexpression as a Tool to Elucidate Gene Function; Transient expression, Transgenics.

UNIT VI
Proteomics: Networking of Biotechnology for interpreting gene functions. Yeast two hybrid systems to study protein –protein interaction to study gene functions, Proteomics as a Functional Genomics Tool, Crystallographic and NMR approaches to determine protein structures.

UNIT VII
Functional characterization of genes associated with important cellular processes influencing crop growth and development.

UNIT VIII
Case studies of genes controlling photosynthesis, respiration, photorespiration, fatty acid biosynthesis, nutrient uptake, flowering, seed protein quality and quantity.

Suggested Readings
Selected articles from various journals

PP 602 SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES

Objective
To impart the knowledge about signal ling of hormones and regulation of physiological processes.

Theory

UNIT I
UNIT II
Hormone signaling: Hormone binding receptors-Transduction process. Effector molecules and gene expression.

UNIT III
Specific signaling pathways of Auxins, Cytokinins, Gibberllins, Ethylene, ABA, brassinosteroids which leads to formative effects. The cross talk in the signaling of different hormones-significance of studies with hormone action mutants.

UNIT IV

UNIT V

UNIT VI
Cross talk between signaling pathways.

UNIT VII
Signal perception and transduction in plant defense responses: Role of salicylic acid and active oxygen species.

UNIT VIII
Signaling cascade during leaf senescence, abscission, flowering and tuberisation

UNIT IX
Transcription factor as signaling regulatory tools for improving growth processes-Case studies: Tbi- lateral branch development, Shi 4- grain shattering, GA1- Dwarfing,MADS, KNOX- flowering development, HAT 4- Shade development, AP2-EREBP- biotic/abiotic stresses.

Suggested Readings
Selected articles from various journals.

PP 603 MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS 2+1

Objective
To impart knowledge to improve the physiological traits using molecular approaches.

Theory
UNIT I
Importance of Molecular Breeding for complex multi-gene controlled physiological traits and its relevance in augmenting trait based breeding. Physiological traits with relevance to
growth, development, abiotic stress tolerance, nutrient acquisition, Approaches for accurate phenotyping of large germplasm accessions and/or mapping populations.

UNIT II
The advantages of “Trait based” breeding approaches. Concept of segregation, independent assortment and linkage. The concept of molecular markers, various types of Dominant and Co-dominant marker systems.

UNIT III
Relevance and development of mapping populations and genetic analysis using marker systems. Advantages of association mapping and the concept of linkage, LD decay and population structure.

UNIT IV
Statistical analysis to assess the variance in phenotypic traits and molecular data. Assessment of genetic parameters such as heritability, genetic advance etc.

UNIT V
Strategies for QTL introgression and Marker Assisted Selection (MAS). Map based cloning of novel genes and alleles. Allele mining

UNIT VI
Transgenic approach in improving physiological processes- Introduction to GMOs and application in crop improvement; gene mining, sequence structure & function analysis using bioinformatics tools, identification of candidate genes for various physiological process associated with specific traits (such as stress tolerance) and their potential benefits in transgenic crops.

UNIT VII
Cloning full-length candidate genes, stress inducible promoters, strategies to clone and characterize and make constructs for specific crops, gene stacking strategies, tissue specific expression and functional validation of genes.

UNIT VIII
Transformation of crop plants- Agrobacterium and use of other organisms for transformation- particle gun transformation and other methods.

UNIT IX
Selection of transformants- molecular analysis on the basis of qRT-PCR, Southern, Northern analysis and immunoassays; estimation of copy number. Concept of desirable number of independent events.

UNIT X
Evaluation of transgenics on basis of empirical/physiological/biochemical process under specific conditions on the basis of gene function. Generation of T1 populations, event characterization and generation of molecular data as per the regulatory requirements.

UNIT XI
Issues related to Biosafety and Registration of Transgenic Agricultural Organisms, methods to detect GMOs from agricultural products.
Practical


Suggested Readings

Selected articles from various journals.

**PP 604 **

**TECHNIQUES IN PLANT PHYSIOLOGY**

**Objective**

To impart recent practical training to study various physiological processes in plants.

**Practical**

Photosynthetic gas exchange measurements, light and CO2 response curves - determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements. Estimation of water use efficiency at whole plant and single leaf level. Use of stable and radioactive isotopes to understand physiological processes. DNA & RNA isolation, cDNA synthesis & library construction, semiquantitative & quantitative RT-PCR, northern blot, immunoassays; techniques for defined physiological processes, Quantification of mineral nutrients using advanced instruments like AAS.

**Suggested Readings**


**PP 605**

**CLIMATE CHANGE AND CROP GROWTH**

**Objective**

To impart knowledge about climate change and its implication to crop growth.

**Theory**

**UNIT I**

History and evidences of climate change and its implications. Effect of climate change on monsoons, hydrological cycle and water availability.
UNIT II
Natural and anthropogenic activities and agricultural practices on GHG production, Monitoring of greenhouse gases and their influence on global warming and climate change, Ozone depletion leading to increased ionizing radiations and its implications on crop growth.

UNIT III
Long-term and short-term projections of climate change effects on natural vegetations and ecosystems, crop-pest interaction, area shift, food production and supply.

UNIT IV
Approaches to mitigate climate change through studies on plant responses.

UNIT V
Direct and indirect effects of climate change on plant processes – phenology, net carbon assimilation, water relations, grain development and quality, nutrient acquisition and yield.

UNIT VI
Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of “Genome wide mutants” to identify genes/processes for improved adaptation to changing environments

UNIT VII
International conventions and global initiatives on Carbon sequestration, carbon trading.

Suggested Readings
Reddy KR & Hodges HF. 2000. Climate Change and Global Crop Productivity. CABI.

PP 606 POST HARVEST PHYSIOLOGY 2+0

Objective
To impart knowledge about physiological changes during senescence and ripening.

Theory
UNIT I
Environmental factors influencing senescence, ripening and post harvest life of flowers, vegetables and seeds.

UNIT II
Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening.

UNIT III
Senescence associated genes and gene products.
UNIT IV
Functional and ultrastructural changes in chloroplast membranes, mitochondria and cell wall during senescence and ripening.

UNIT V
Regulatory role of ethylene in senescence and ripening, ethylene biosynthesis, perception and molecular mechanism of action.

UNIT VI
Post harvest changes in seed and tubers biochemical constituent’s quality parameters. Effect of environmental factors on post harvest changes in seed and tubers.

UNIT VII
Biotechnological approaches to manipulate ethylene biosynthesis and action.

UNIT VIII
Alternate post harvest methodology and quality attributes. Scope for genetic modification of post harvest life of flowers and fruits.

UNIT IX
Uses of GM crops and ecological risk assessment.

Practical
Physiological and biochemical changes during senescence and ripening, Estimation of ethylene during senescence and ripening, determination of Reactive Oxygen Species and scavenging enzymes, Measurement of dark and alternate respiration rates during senescence and ripening. Estimation of ripening related enzyme activity, Cellulases pectin methyl esterases, polygalacturonase etc.

Suggested Readings

PP 607 WEED PHYSIOLOGY AND HERBICIDE ACTION 1+1

Objective
To apprise students regarding weed and crop competition, and physiological and molecular aspects of herbicides.

Theory
UNIT I
Weed biology, ecology and physiology. Weed and crop competition, allelochemicals, their nature and impact. Weed-seed physiology.

UNIT II
Classification of herbicides and selectivity. Recent concepts on entry, uptake, translocation and metabolism of soil and foliar applied herbicides. Environmental and plant factors influencing entry, uptake and translocation of herbicides.
UNIT III
Classification and chemistry of common herbicides. Physiological, biochemical and molecular mechanism of action of different groups of herbicides; ACC synthase inhibitors, ALS inhibitors, Mitotic inhibitors, Cellulose biosynthesis inhibitors, Inhibitors of fatty acid biosynthesis, inhibitors of Photosynthesis, Auxinic Herbicides, New herbicides.

UNIT IV
Metabolic pathway of herbicide degradation in plants and soil. Herbicide adjuvants and their classification.

UNIT V
Molecular mechanism of action of herbicide synergists and antagonists.

UNIT VI
Physiological and molecular mechanism of herbicide selectivity.

UNIT VII
Herbicide resistant crops; transgenic & tissue culture approaches to develop herbicide tolerant varieties

Practical
Adjuvants and their effect on spray droplets, chemical entry and transport. Determination of physiological and biochemical processes like photosynthesis, respiration, cell division, Protein & fatty acid synthesis, membrane permeability as affected by herbicides. Quantification of pigment levels in leaves, specific enzyme activities affected by herbicides. Demonstration of translocating type of herbicides by radio labeling studies.

Suggested Readings

PP 608 SEED PHYSIOLOGY 2+1

Objective
To apprise students regarding seed germination, dormancy and physiological processes involved in regulation of seed development

Theory
UNIT I
Seed and fruit development, seed and fruit abortion, proximate mechanism of seed and fruit abortion. Hereditary and environmental effect on seed development. Gene imprints and seed development.

UNIT II
Importance of seeds, seed structure and function, physiological and biochemical changes, environmental influences, physiology of seed and fruit development; seed and fruit abortion and means to overcome it; proximate mechanisms of seed and fruit abortion.
UNIT III
Structure of seeds and their storage resources, seed developmental patterns and source of assimilates for seed development.

UNIT IV
Pathway of movement of assimilates in developing grains of monocots and dicots, Chemical composition of seeds, Storage of carbohydrates, proteins and fats in seeds and their biosynthesis.

UNIT V
Seed respiration, mitochondrial activity, Seed ageing, Mobilization of stored resource in seeds, Chemistry of oxidation of starch, proteins and fats, Utilization of breakdown products by embryonic axis.

UNIT VI
Control processes in mobilization of stored resources, Role of embryonic axes, Gibberlin and a-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, Role of LEA proteins.

UNIT VII
Seed viability, Physiology of and means to prolong seed viability, Seed vigour: concept, importance, measurement; invigoration: methods and physiological basis of it, 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 amylase activity, Protease and lipase activity in germinating seeds, Seed viability test and accelerated ageing test. Seed hardening/osmotic priming of seeds, Seed respiration rates, Seed viability losses through membrane leakage studies.

Suggested Readings
Copeland LO & McDonald MB. Principles of Seed Sciences and Technology. Burgers Publ. Co.

List of Journals
American Journal of Botany
Annals of Arid Zone
Annual Review of Plant Physiology and Plant Molecular Biology
Australian Journal of Agricultural Research
Australian Journal of Biological Sciences
Australian Journal of Botany
Australian Journal of Plant Physiology
Biochemie und Physiologie der Pflanzen
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Suggested Broad Topics for Master’s and Doctoral Research

**Environmental stress physiology-** Salt, Drought, Heat, Freezing, and Heavy Metal

- Nodulation and nitrogen fixation in leguminous plants
- Physiology of senescence and abscission in crop plants especially in cotton
- Phytoremediation, especially with reference to salt and heavy metal stress
- Ecophysiology of tree species to evaluate bio-drainage potential of plants under waterlogged saline area

**Growth and development of crop plants**

- Mineral nutrition in crop plant
- Application of plant growth regulators to improve crop productivity
- Photosynthesis, respiration and related processes for crop improvement