CROP PHYSIOLOGY
Course Structure –at a Glance

CODE	COURSE TITLE	CREDITS
*PP.501	PRINCIPLES OF PLANT PHYSIOLOGY- I : CELL ORGANELLES, WATER RELATIONS AND MINERAL NUTRITION	2+1
*PP.502	PRINCIPLES OF PLANT PHYSIOLOGY- II:METABOLIC PROCESSES AND GROWTH REGULATION	2+1
*PP.503	PLANT DEVELOPMENTAL BIOLOGY – PHYSIOLOGICAL AND MOLECULAR BASIS	2+0
*PP.504	PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES	2+1
*PP.505	HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT	2+1
*PP.506	PHYSIOLOGY OF GROWTH, YIELD AND MODELING	1+1
PP.507	GENOME ORGANIZATION IN HIGHER PLANTS	2+1
*PP.508	MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION	1+1
PP.509	PHYSIOLOGY OF CROP PLANTS – SPECIFIC CASE STUDIES	2+0
PP.510	PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS – CARBON AND NITROGEN ASSIMILATION	1+1
PP.511	MINERAL NUTRITION	2+1
PP.591	MASTER'S SEMINAR	1+0
PP.599	MASTER'S RESEARCH	20
**PP.601	FUNCTIONAL GENOMICS AND GENES ASSOCIATED WITH A FEW PHYSIOLOGICAL PROCESSES	2+0
**PP.602	SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES	2+0
**PP.603	MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS	2+1
PP.604	TECHNIQUES IN PLANT PHYSIOLOGY	0+2
PP.605	CLIMATE CHANGE AND CROP GROWTH	2+0
PP.606	POST-HARVEST PHYSIOLOGY	2+0
PP.607	WEED PHYSIOLOGY AND HERBICIDE ACTION	1+1
PP.608	SEED PHYSIOLOGY	2+1

CODE	COURSE TITLE	CREDITS
PP.691	DOCTORAL SEMINAR – I	1+0
PP.692	DOCTORAL SEMINAR- II	1+0
PP.699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme; ** Compulsory for Ph. D. programme

Minor Departments **9**

Biochemistry

Genetics & Plant Breeding

Plant Molecular Biology and Biotechnology

Supporting Departments **5**

Statistics and Mathematics

Microbiology

Agronomy

Computer Science.

Non credit compulsory courses

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATION SKILLS	0+1
PGS 503 (e-course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-course)	DISASTER MANAGEMENT	1+0

PP 501 PRINCIPLES OF PLANT PHYSIOLOGY – I : 2+1
CELL ORGANELLES, WATER RELATIONS AND MINERAL NUTRITION

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

Plant water relations – importance and properties of water – cell water terminology – water potential and its components – growth of cells and water relations - Movement of water in plants mechanism of water uptake and transport – role of roots – factors affecting root growth and proliferation

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

Plant Cell – a general view, Structure of cell organelles, Anatomy of plant roots, Measurement of water status: Relative water content, Measurement of water potential : Chardakov's falling drop method, Scholander's Pressure chamber method, Osmometer method, Measurement of transpiration (steady state porometer or IRGA), Solar energy absorption in plant – leaf level and canopy level, Effect of ABA on stomata, Effect of water stress on seed germination and seedling growth, Mineral nutrients: Development of deficiency symptoms of plant nutrients (2 classes), Development of toxicity symptoms of plant nutrients, Influence of pH and EC on plant growth in solution culture

Suggested Readings

Barker AB & Pilbeam DJ. 2007. *Handbook of Plant Nutrition*. CRC

Epstein E. 2007. *Mineral Nutrition of Plants*. John Wiley & Sons.

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Marschner H. 1995. *Mineral Nutrition of Higher Plants*. Academic Press.

Salisbury FB & Ross C. 1992. *Plant Physiology.* 4th Ed. Wadsworth Pub.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

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

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

Carbon metabolism: The C_3 photosynthetic carbon reduction cycle – Calvin cycle. Supplemental pathway of carbon fixation in C_4 and CAM plants and its significance – Further modeling of photosynthesis.

UNIT IV

Photosynthesis as a diffusive process (gas & liquid phase diffusion). Effect of environmental factors on photo synthetic rates (CO_2 response curves and light response curves) – Discrimination of carbon isotopes in plants. Photo respiration and its relevance

UNIT V

Synthesis of sucrose, starch, oligo and polysaccherides from triose phosphate generated by the C_3 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

Mitochondrial respiration – Introduction – General characteristics of respiration system – respiratory substrates – glycolytic pathway – anaerobic respiration.

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 (N_2, NO_3 & NH_3) 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

Physiology of flowering – photoperiodism – induction and perception of stimulus – classification of plants based on photoperiodic responses – role of phytochrome, Florigen and GA in photoperiodic response – Vernalisation – Vernalisation stimulus – Perception – shoot apex – its importance in flowering

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

Kabita Datta 2007. *Plant Physiology*. Mittal Publ.

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury FB & Ross C. 1992. *Plant Physiology.* 4th Ed. Wadsworth Publ.

Srivastava L.M. 2002. *Plant Growth and Development: Hormones and Environment.* Academic Press.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

Wareing PF & Phillips IDJ. 1981. *Growth and Differentiation in Plants*. 3rd Ed.Pergamon Press.

Wilkins MB. 1969. *Physiology of Plant Growth and Development.* Tata McGraw-Hill.

PP 503 PLANT DEVELOPMENTAL BIOLOGY-PHYSIOLOGICAL AND MOLECULAR BASIS 2+0

Objective

To explain about bsisc 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 plnts.

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.

Srivastava L.M. 2002. *Plant Growth and Development: Hormones and Environment.* Academic Press.

Taiz L & Zeiger E, 2006. *Plant Physiology.* 4th Ed. Sinauer Associates. Wareing PF & Phillips IDJ, 1981. *Growth and Differentiation in Plants.* 3rd Ed. Pergamon Press.

Wilkins MB, 1969, *Physiology of Plant Growth and Development.* Tata McGraw-HIll.

PP 504 PHYSIOLOGICAL AND MOLECULAR RESTONSES OF PLANTS TO ABIOTIC STRESSES 2+1

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

Drought - characteristic features, Water potential in the soil -Plant air continuum. Development of water deficits, energy balance concept.

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

Chilling stress: Effects on physiological processes. Crucial role of memberane lipids.

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 O_2 evolution of chloroplasts - as a screening techniques for chilling tolerance.

Suggested Readings

Hopkins WG &Huner NPA, 2004. *Introduction to Plant Physiology,* John Wiley & Sons.

Salisbury FB & Ross C. 1992. Plant Physiology. 4th Ed. Wadsworth Publ.

Taiz L & Zeiger E. 2006. Plant Physiology, 4th Ed. Sinauer Associates.

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, cytokinnis - cell division, Retardation of senescence of plant parts, Abscisic acid - Stomatal closure and induction of drought resistance, Ethylene - fruit ripening.

UNIT V

Interaction of hormones in regulation of plant growth and development processes. Rooting of cuttings - Flowering. Apical dominance, molecular aspects of control of reproductive growth and development.

UNIT VI

Syntheitc 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 onrooting 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 bioassaysestimation 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

Hopkins WG & Huner NPA, 2004. *Introduction to Plant Physiology.* John Wiley & Sons.

Salisbury FB & Ross C. 1992. *Plant Physiology.* 4th Ed. Wadsworth Publ. Taiz OL & Zeiger E.2006. *Plant Physiology.* 4th Ed. Sinauer Associates.

PP 506 PHYSIOLOGY OF GROWTH AND YIELD AND MODELING 1+1

Objective

To impart knowledge regarding crop growth analysis and different yield prediction models.

Theory

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

Gardner FP, Pearce RB & Mitchell RL. 1988. *Physiology of Crop Plants*. Scientific Publ. Goudriaan J & Van Laar HH. 1995. *Modelling Potential Crop Growth*

Processes. (Textbook with Exercises) Series: *Current Issues in Production Ecology.* Vol. II. Kluwer.

Hunt R. *Plant Growth Curve - The Fundamental Approach to Plant Growth Analysis*. Edward Arnold.

John H, Thornley M & Johnson IR. *Plant and Crop Modeling: A Mathematical Approach to Plant and Crop Physiology*. Blackburn Press.

Vos J, Marcelis LFM, Visser PHBD, Struik PC & Evers JB. (Eds.). 2007.

Functional-Structural Plant Modelling in Crop Production. Vol. XXII. Springer.

PP 507 GENOME ORGANIZATION IN HIGHER PLANTS 2+1

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, autoptetraploids and polyploids.

UNIT II

Gene & gene expression: Diversity in DNA polymerases; control of plasmid copy number; Regulation of transcription in prokayotes; 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 retroptransposans; Repairand 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 bactriophage; studis on lytic and lysogenic phages.

Suggested Readings

Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith

Roberts & Peter Walter. *Molecular Biology of the Cell*. 3rd Ed. Garland Science.

PP 508 MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION 1+1

Objective

To impart knowledge about cellular basic of growth and morphogenesis in plants.

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

Introduction to the processes of embryogenesis and organogenesis and their practical applications : Clonal Multiplication of elite species (micropropagation) – axillary bud, shoot – tip and meristem culture. Haploids and their applications. Somaclonal variations and applications (treasure your exceptions).

UNIT V

Introduction to protoplast isolation : Principles and applications . Testing of viability of isolated protoplast . Various steps in the regeneration of protoplast . Somatic hybridization – an introduction, Various methods for fusing protoplast, chemical and electrical . Use of makers for selection of hybrid cells. Practical applications of somatic hybridization (hybrids vs cybrids)

UNIT VI

Use of plant cells, protoplast and tissue culture for genetic manipulation of plant : Introdiuction 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 ethlyne on callus induction, organogenesis; Somatic embryogenesis, Effect of growth conditions such as temperature and photoperiod on organogenesis, Single – cell suspension cultures.

Suggested Readings

Bajaj YPS. (Ed.). 1991. *Biotechnology in Agriculture and Forestry*. Vol. XIV. Springer-Verlag.

Rajdan MK. 1993. *Plant Tissue Culture*. Oxford & IBH.

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

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

Gardner FP, Pearce RB & Mitchell RL. 1988. *Physiology of Crop Plants*. Scientific Publ.

Pessarakli M. *Handbook of Plant and Crop Physiology*. CRC Press.

Selected reviews and articles from Periodicals and Journals.

PP 510 PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS-CARBON AND NITROGEN ASSIMILATION 1+1

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

Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes Genes regulating potential traits of photosynthesis, biotechnological approaches for improving photosynthetic rate and productivity – transgenics. Conceptual approaches of expressing C4 photosynthesis genes in C3 species.

UNIT VII

Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo inhibition, photo oxidation, excitation energy dissipation mechanisms, photochemical and no-photochemical quenching of chlorophyll fluorescence. Photosynthesis and transpiration interaction, significance of WUE, carbon isotope discrimination concept.

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

Extraction and separation of plant pigments, Isolation of chloroplasts ETC reactions- O2 evolution, Determination of rubisco content (western and ELISA), activity and activation state, Enzymatic determination of starch and sucrose, Determination of photosynthetic rates –gas exchange. A, gs, Ci, A/gs, C/gs- intrinsic WUE by gas exchange rates. Light, CO2, VPD response curves, Determination of photorespiration by gas exchange- (TPSAPS). Genotypic/species differences in photosynthetic rates. Measurement of radiation, Eu% light interception, Determination of NH4 +, reduction of inorganic nitrogen species.

Suggested Readings

Edwin Oxlade & Graham Lawler (year). *Plant Physiology: The Structure of Plants Explained.*
John Wiley & Sons.

Hopkins WG & Huner NPA.2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury FB & Ross C.1992. *Plant Physiology.* 4th Ed. Wadsworth Publ.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

PP 511 MINERAL NUTRITION 2+1

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

Barker AB & Pilbeam DJ. 2007. *Handbook of Plant Nutrition*. CRC

Epstein E. 2007. *Mineral Nutrition of Plants*. John Wiley & Sons.

Marschner H. 1995. *Mineral Nutrition of Higher Plants*. Academic Press.

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

Gene discovery: Finding Genes in Complex Plant System, Constructing Gene-Enriched Plant Genomic Libraries, In Silico Prediction of plant Gene Function, Quantitative Trait Locus Analysis as a Gene Discovery Tool.

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 2+0

Objective

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

Theory

UNIT I

General aspects: Introduction to signaling-Long range (Diffusible) signaling and short range (contact) signaling. Components of signaling- Upstream components: receptor and ligands concept-types of ligands and its relevance-receptor kinases-Two component sensing system. Down stream components: G. proteins-second messengers-Cyclic AMP, adenylate cyclase cascade, cyclic GMP, calcium-calmodulin-Kinases-Effector molecules (transcription factor).

UNIT II

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

UNIT III

Specific signaling pathways of Auxins, Cytokinisn, 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

Light signaling: Perception of light-pigments involved-activation of phytochrome/ cryptochrome (study of mutants). Light signal transduction- Multiple signaling cascades-identification of signaling components through mutant analysis-changes in gene expression.

UNIT V

Abiotic stress signaling: Sensing of environmental factors (Temperature- Osmoticum-Ionic stress) Activation of specific molecules and secondary messengers-Activation of Down stream components-leading to stress gene expression. Case studies with different abiotic stresses.

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

Phenotyping approaches for the different physiological traits. Genotyping options using gene-scan systems. Development of SSR, SNP and SCAR markers, resolution of polymorphism on agarose gels and PAGE, genotyping using a DNA sequencing machine, scoring of gels and assessment of polymorphism, Statistical approaches to assess genetic variability, heritability and other parameters, Phylogenic analysis, Principal component analysis and construction of dendrograms. Construction of Linkage map, QTL maps, population structure, LD decay etc leading to identification of QTLs, Bioinformatics – sequence analysis, structure analysis, Molecular biology - genomic/plasmid DNA isolation, RNA isolation. Full-length gene cloning, vector construction with specific promoter, gene stacking & transient assays. Transformation in model system,Crop transformation - *Agrobacterium* mediated transformation (inplanta & invitro), particle-gun transformation, Evaluation of transgenics – semiquantitative & quantitative RT-PCR, southern blot, northern blot, western blot and ELISA, biochemical/physiological assay based on the function of gene & testing LOD.

Suggested Readings

Selected articles from various journals.

PP 604 TECHNIQUES IN PLANT PHYSIOLOGY 0+2

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

Dhopte MA & Manuael Livera M. 1986. *Useful Techniques for Plant*

Scientists. Forum for Plant Physiologists, R. D. G., Aloka.

PP 605 CLIMATE CHANGE AND CROP GROWTH 2+0

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

Abrol YP & Gadgil S. (Eds.). 1999. *Rice in a Changing Climate*.

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

Watson RT, Zinyowera MC & Moss RH. 1998. *The Regional Impacts of Climate Change - an Assessment of Vulnerability.* Cambridge Univ. Press.

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

Jeffrey K Brecht & Weichmann J. 2003**.** *Post Harvest Physiology and Pathology of Vegetables.* CRC Press.

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

Devine MD, Duke SO & Fedtake C. 1993. *Physiology of Herbicide Action*. Prentice Hall.

Monaco TJ, Weller SC & Ashton FM. 2002. *Weed Science - Principles and Practices*. Wiley.com Publ.

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, Gibberllin 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 aamylase 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

Bewley JD & Black M. 1985. *Seed Physiology of Development and Germination*. Plenum Publ.

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

Srivastav L M. Plant Growth and Development - Hormones and Environment, Academic Press.

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

Biologia Plantarum
Botanical Gazette
Botanical Review
Canadian Journal of Agricultural Research
Canadian Journal of Botany
Canadian Journal of Plant Science
Communications in Soil Science and Plant Analysis
Current Science
Environmental and Experimental Botany
Euphytica
Experimental Agriculture
Experimental Cell Biology
Functional Plant Biology
Indian Journal of Agriculture
Indian Journal of Experimental Biology
Indian Journal of Plant Physiology
International Journal of Botany
Japanese Journal of Crop Science
Journal of Agricultural and Scientific Research
Journal of Agricultural Science
Journal of Arid Environment
Journal of Experimental Botany
Journal of Plant Biology
Journal of Plant Nutrition
Nature
New Physiologist
Physiologia Plantarum
Physiology and Molecular Biology of Plants
Plant and Cell Physiology
Plant and Soils
Plant Cell, Tissue and Organ Culture
Plant Growth Regulator abstracts
Plant Physiology and Biochemistry
Plant Science
Plant Science (India)
Science Journal
Seed Science and Technology
Seed Science Research

Soil Science and Plant Nutrition
Soviet Plant Physiology
Trends in Plant Science
Tropical Agriculture

e-Resources

www.Bioone Online Journals The Arabiopsis Book.
www. Botany on line:
www.Ingenta Connect Physiologia Plantarum
www.new.phytologist.org.
www.plant physiol.org.
www.mpiz-Kolen.mpg.de.
www.Science Direct.
www.Scientia Agricolo.
www.wiley interscience.

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