

20 Plant Physiology

TRIMESTERWISE DISTRIBUTION OF COURSES

I TRIMESTER

	L	P
AGR 006 CROP MORPHOLOGY AND PHYSIOLOGY	1	1
PP 501 PRINCIPLES OF PLANT PHYSIOLOGY-I	4	1
PP 502 PLANT DEVELOPMENTAL BIOLOGY	3	1
PP 506 PHYSIOLOGY OF CROP PLANTS- II	2	0
PP 507 PHOTOSYNTHESIS	2	0
PP 601 TECHNIQUES IN PLANT PHYSIOLOGY -I	1	2
PP 602 RESPONSES OF PLANTS TO ABIOTIC STRESSES	2	1
PP 691 SEMINAR	1	0

II TRIMESTER

PP 503/ GLOBAL CLIMATE CHANGE AND AGRICULTURE ES 503	2	1
PP 504 HORMONAL REGULATIONS OF PLANT GROWTH AND DEVELOPMENT	3	1
PP 505 PHYSIOLOGY OF GROWTH AND YIELD	2	1
PP 508 PHYSIOLOGY OF PLANT MINERAL NUTRITION	3	2
PP 603 PRINCIPLES OF PLANT PHYSIOLOGY – II	3	0
PP 691 SEMINAR	1	0

III TRIMESTER

PP 509 PHYSIOLOGY OF CROP PLANTS-I	2	0
PP 604 TECHNIQUES IN PLANT PHYSIOLOGY -II	1	3
PP 605 PLANT METABOLISM	3	0
PP 607/ PHYSIOLOGY AND BIOCHEMISTRY OF HERBICIDES ACTION AG 607	3	1
PP 608/ PHYSIOLOGY OF SEEDS SST 608	2	1

PP 617/ PHYSIOLOGY OF RIPENING AND SENESCENCE PHT617	2	1
PP621/ GROWTH AND DEVELOPMENT OF HORTICULTURAL CROPS HORT 621	3	2
PP 691 SEMINAR	1	0

Core Courses

M.Sc.: PP 501, PP 505, PP 508, PP 601, PP 603 and BIO 501

Ph.D.: PP 505, PP 602 and PP 605

PLANT PHYSIOLOGY

Major Field : Plant Physiology

Minor Field : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR 006 CROP MORPHOLOGY AND PHYSIOLOGY

(1L+1P) I

Objective

To acquaint non- agriculture students with basics of plant morphology and physiological processes occurring in the plant.

Theory

UNIT I

Plant cell structure and function, morphology and anatomy of root, stem, leaf and flower

UNIT II

Pollination, fertilization, embryology, seed and its physiology.

UNIT III

Plant growth and development, plant growth regulators

UNIT IV

Water relations, photosynthesis, respiration and mineral nutrition in plants

Practicals

Anatomical features of root, stem, leaf and flower, cell structure, taxonomical description of flower, emasculation and artificial pollination, growth analysis, water relations, measurements of chlorophylls, photosynthesis and respiration, nutrient deficiency symptoms in crop plants.

Suggested Readings

Bhojwani, S.S. and Bhatnagar, S.P. 1992. The Embryology of Angiosperm. Vikas Publishing House, New Delhi.

Dutta, A.C. 2000. Botany: For Degree Students. Oxford University Press, Calcutta.

Esau, K. 1977. Anatomy of Seed Plants, 2nd ed. Wiley, New York.

Fahn, A. 1982. Plant Anatomy, Pergamon Press, Oxford.

Ganguli, H.S., Das, K.S. and Dutta, C.T. 1981. College Botany Vol. I. New central Agency, Calcutta.

Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., New York

Linda R. Berge 2009. Brooks Cole Publishing Company, California, USA.

Mauseth, J.D. 2003. Botany: An Introduction to Plant Biology. Jones and Bartlett Publishers International, London, U.K.

Pandey, B.P. 2004. A text book of Botany. S.S. Chand Co. Pvt. Ltd., New Delhi.

Salisbury, F.B. and Ross, C.W. 1986. Plant Physiology, CBS Publishers & Distributors, New Delhi.

Taize, L. and Zeiger, E. 2006. Plant Physiology. Sinauer Associates, Inc, Publishers, Sunderland, Massachusetts, USA.

Tayal, M.S. 1983. Plant Anatomy. Rastogi Publication, Meerut.

PP 501 PRINCIPLES OF PLANT PHYSIOLOGY-I

(4L+1P) I

Objective

To acquaint the students with the basic concepts of plant physiology and their application in agriculture.

Theory

UNIT I

Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions.

UNIT II

Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells. Mechanism of water uptake by roots-transport in roots, aquaporins, movement of water in plants – Mycorrhizal association on water uptake. Water loss from plants-Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration, transpiration –Driving force for transpiration, plant factors influencing transpiration rate.

UNIT III

Stomata structure and function – mechanism of stomatal movement, antitranspirants. Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance. The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants.

UNIT IV

Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants. Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition.

UNIT V

Photosynthesis and its importance in bio productivity. Photochemical process, photochemical reactions, CO₂ reduction in Calvin cycle, supplementary pathway of C fixation in C₄ and CAM plants and its significance. Photorespiration and its relevance. Photosynthesis as a diffusive process, effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall). Translocation of photosynthates and its importance in sink growth. Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance.

UNIT VI

Nitrogen metabolism: Inorganic nitrogen species (N_2 , NO_3 and NH_3) and their reduction to amino acids, protein synthesis and nucleic acids. Lipid metabolism- Storage, protective and structural lipids. Biosynthesis of fatty acids, diacyl and triacyl glycerol, fatty acids of storage lipids. Secondary metabolites and their significance in plant defense mechanism. Growth and differentiation.

UNIT VII

Hormonal regulation of growth and differentiation, plant growth hormones and their physiological role, synthetic growth regulators, growth retardants, apical dominance, senescence, fruit growth, abscission. Photomorphogenesis: Photoreceptors, phytochrome, cryptochrome. Physiology of flowering: Photoperiodism and vernalization.

Practicals

Estimation of plant water status: Relative water content, water potential estimation by pressure chamber/ psychrometer, membrane stability index (MSI) by conductivity meter. Growth parameters: Growth parameters measurement, growth analysis. Photosynthesis and related parameters: Estimation of chlorophyll/ carotenoid content, separation of photosynthetic pigment using paper chromatography, photosynthesis measurements by IRGA, respiration rate measurement. Amino Acid and proteins: Estimation of total free amino acids, estimation of proteins by Lowry/ Bradford method. Nitrogen metabolism: *In vivo* nitrate reductase activity assay, nitrogenase activity assay by gas chromatography.

Suggested Readings

Salisbury, F.B. and Ross, C.W. 1986. Plant Physiology, CBS Publishers & Distributors, New Delhi.

Taize, L. and Zeiger, E. 2006. Plant Physiology. Sinauer Associates, Inc, Publishers, Sunderland, Massachusetts, USA.

PP 502 PLANT DEVELOPMENTAL BIOLOGY

(3L+1P) I

Objective

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

Theory

UNIT I

Shoot, leaf and root development – Organization of shoot/root apical meristem

UNIT II

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

UNIT III

Senescence and programmed cell death (PCD) – Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

UNIT IV

Photomorphogenesis, phototropism, photonasty and leaf movement, chlorophyll synthesis, 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 V

Special aspects of plant development and differentiation – Regeneration and totipotency; Organ differentiation and development, Sex determination in plants; Self-incompatibility and its genetic control; Heterosis and apomixis.

Practicals

Role of light on growth and development. Effect of day length on transition from vegetative to reproductive phases in wheat. Analysing the effect of GA on phenological development. Effect of ABA on growth and development of flowers. Changes in level of pigments under different light conditions. Application of vernalization during induction of flowering. Importance of photoperiodism in agriculture.

Suggested Readings

Bernier, G. 1988. The control of floral evocation and morphogenesis. *Annu. Rev. Plant Physiol. Plant Mol. Biol.* 39: 175-219.

King, R.W. and Evans, L.T. 2003. Gibberellins and flowering of grasses and cereals: Prizing the lid of the “Florigen” black box. *Ann. Rev Plant Biol.* 54: 307-328.

Komeda, Y. 2004. Genetic regulation of time to flower in *Arabidopsis thaliana*. *Annu. Rev. Plant Biol.* 55: 521-535.

Lang, A. 1965. Physiology of flower initiation. In *Encyclopedia of Plant Physiology* 15/1, W. Ruhland, ed (Berlin: Springer), pp. 1380-1536.

Taize, L. and Zeiger, E. 2006. Plant Physiology. Sinauer Associates, Inc, Publishers, Sunderland, Massachusetts, USA.

Zeevaart, J.A.D. 1976. Physiology of flower formation. *Annu. Rev. Plant Physiol.* 27: 321-348.

Zeevaart, J.A.D. 2006. Florigen coming of age after 70 years. *Plant Cell* 18: 1783-1789.

PP 503/ES 503 GLOBAL CLIMATE CHANGE AND AGRICULTURE

(2L+IP)

Objective

To impart theoretical and practical knowledge about the evidence, causes and impact of climate change and its adaptation and mitigation options

Theory

UNIT I

Definition and concept of climate change and variability; global warming and dimming; science and politics of climate change and international conventions; evidence, scenario and causes of climate change

UNIT II

Greenhouse gases and mechanism of their production and emission from various agro-ecosystems, source and sinks of GHG; warming potential and contribution of greenhouse gases to global warming, greenhouse effect; monitoring of greenhouse gases

UNIT III

Impact assessment of rise in atmospheric temperature and CO₂ on growth, physiological processes, productivity and quality of different crops, soil health, water availability, insect pest dynamics, crop-weed competition, milk and inland and marine fish production; climate change and loss of biodiversity; spatial and temporal changes in agricultural production in context of climate change.

UNIT IV

Evidence and causes of global dimming; causes of global dimming; impact assessment of global dimming on crop productivity, quality and crop- pest interaction.

UNIT V

Adaptation and mitigation options to climate change; carbon sequestration; modeling climate change and its impact on crops. International summit, conferences, protocols and negotiations on climate change; clean development mechanism; carbon trading, credits, footprints and govt. strategies and policies on climate change management.

Practicals

Measurement of CO₂ from crop fields, measurement of CH₄ from crop fields, measurement of N₂O from crop fields, measurement of O₃ from crop fields, recent techniques for assessing the impact of high temperature on crops, recent techniques for assessing the impact of CO₂ fertilization on crops, recent techniques for assessing the impact of elevated O₃ on crops, modelling impact of high temperature and CO₂ on crop yield, modelling impact of high temperature on soil and water, modelling impact of high CO₂ on soil and water.

Suggested Readings

IPCC Assessment Report 2007

Climate change Journal Climate Change: Source, impact and policy, Proceeding of 2nd World Climate Conference. Ed. by J. Jager and H.L. Ferguson, Cambridge University Press, 1993

Greenhouse gas emission from agricultural system, Published by IPCC- USEPA

Climate change and global crop productivity ed. by K.R. Reddy and H.F. Hodges

CABI Publishing

Global Warming (Fourth edition) by John Houghton, Cambridge Press

PP 504 HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT

(3L+1P) II

Objective

To apprise the students about structure and function of plant growth regulators.

Theory

UNIT I

Definition and classification of plant growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. Tricentanol, 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, Gibberellins, Cytokinins, Absciscic acid, Ethylene and Brassinosteroids. Hormone mutants and transgenic plants in understanding role of hormones.

UNIT III

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, Absciscic acid-stomatal closure and induction of drought resistance, Ethylene- fruit ripening. Interaction of hormones in regulation of plant growth and development processes.

UNIT IV

Rooting of cuttings-Flowering. Apical dominance, molecular aspects of control of reproductive growth and development. Synthetic growth regulators- Classification, their effect on plant growth and development. Practical utility in agriculture and horticulture.

Practicals

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 dominance and senescence, ABA bioassays estimation using immunoassay technique. ABA effect on stomatal movement, Ethylene bioassays, estimation using physico- chemical techniques- effect on breaking dormancy in sunflower and groundnut.

Suggested Readings

Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. Biochemistry and Molecular Biology of Plants. Am, Soc. Plant Physiologists, Rockville, Maryland.

Davies, P.J. 2004. Plant hormones: biosynthesis signal transduction, action. Kluwer Academic Publishers. The Netherlands.

Srivastava, L M. 2000. Plant Growth and Development - Hormones and Environment, Academic Press.

PP 505 PHYSIOLOGY OF GROWTH AND YIELD

(2L+1P) II

Objective

To impart knowledge regarding growth and yield analysis of crops, yield models-and yield prediction.

Theory

UNIT I

Crop growth analysis and techniques, 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, attenuation of light through crop canopy, energy use efficiency of different canopies. LAI, LAD. Concept of critical and optimum LAI. Plant ideotypes,

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

Yield structure analysis, theoretical and actual yields. Simple physiological yield models-and yield prediction.

Practicals

Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA partitioning 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

Donald, L. Smith and Chantal, Hamel (Eds). 2002. Crop Yields –Physiological Processes. Springer.-Verlag, Berlin

Edward, Arnold, John, H., Thornley, M. and Johnson, I.R. 1997. Plant and Crop Modeling: A Mathematical Approach to Plant and Crop Physiology. Blackburn Press.

Gardner, F.P., Pearce, R.B. and Mitchell, R.L. 1988. Physiology of Crop Plants. Scientific Publishers, Jodhpur.

Goudriaan, J. and Van Laar, H.H. 1995. Modelling Potential Crop Growth Processes. (Textbook with Exercises) Series: Current Issues in Production Ecology. Vol. II. Kluwer.

Hay, R.K.M. and Porter, J.R. 2006. The Physiology of Crop Yield. Blackwell Publisher.

Hunt, R. 1982. Plant growth curves: the functional approach to plant growth analysis. London: Edward Arnold

Vos, J., Marcelis, L.F.M., Visser, P.H.B.D., Struik, P.C. and Evers, J.B. (Eds.). 2007. Functional-Structural Plant Modelling in Crop Production. Vol. XXII. Springer.

PP 506 PHYSIOLOGY OF CROP PLANTS – II

(2L+0P) I

Objective

To impart knowledge of physiological aspects of different crop plants.

Theory

UNIT I

Origin, evolution and distribution of crop, adaptability of crop to different agro climatic conditions. Specific case studies: Oilseeds: rapeseed mustard, groundnut and sunflower. Pulses: mungbean, pigeonpea, soybean cowpea and chickpea)

UNIT II

Crop characteristics-growth and development (both vegetative and reproductive), physiological processes governing productivity

UNIT III

Influence of climatological factors (water, temperature, photoperiod and light) on crop growth attributes and physiological processes.

UNIT IV

Special problems of each crop, crop ideotype concept and source sink relationship

Suggested Readings

Gardner, F.P., Pearce, R.B. and Mitchell, R.L. 1988. *Physiology of Crop Plants*. Scientific Publishers, Jodhpur.

Pessarakli, M. 2002. *Handbook of Plant and Crop Physiology*. Marcel and Dekker Inc. New York

PP 507 PHOTOSYNTHESIS

(2L+0P) I

Objective

To impart knowledge about physiological and molecular aspects of photosynthesis in plants.

Theory

UNIT I

Historical perspective, primary processes in plant photosynthesis, energy transfer, fluorescence, biogenesis and molecular genetics of chloroplast, chloroplast structure and function, chlorophyll biosynthesis

UNIT II

Pigment protein complexes, photosynthetic electron transport, ATP synthesis, oxygen evolution

UNIT III

Carbon fixation, evidences for carbon fixation cycles, metabolism of carbon compounds, photo-regulation of enzymes of carbon fixation, crassulacean acid metabolism,

UNIT IV

Photorespiration and RuBP carboxylase/oxygenase,

UNIT V

Environmental regulation of photosynthesis, genetics and evolution of photosynthesis, photosynthesis and crop productivity, conceptual approaches of expressing C4 photosynthesis genes in C3 spp., biotechnological approaches for improving photosynthetic rate, carbon isotope discrimination concept.

Suggested Readings

Buchanan, B.B. , Gruissem, W. and Jones, R.L. 2000. *Biochemistry and Molecular Biology of Plants*. Am, Soc. Plant Physiologists, Rockville, Maryland.

Dennis, D.T. and Turpin, D.H. 1990. *Plant Physiology, Biochemistry and Molecular Biology*. Longman Scientific and Technical, Longman House, Burnt Mill, Harlow, England.

Lawlor, D.W. 1987. *Photosynthesis, Metabolism, Control and Physiology*. Longman Scientific and Technical Harlow.

Salisbury, F.B. and Ross, C.W. 1986. *Plant Physiology*, CBS Publishers & Distributors, New Delhi.

Steinback, K.E., Bonitz, S., Arntzen, C.J. and Bogorad, L. (Eds.) (1985). *Molecular biology of photosynthetic apparatus*. Cold Spring Harbor, New York, Cold Spring Harbor Laboratory.

Taize, L. and Zeiger, E. 2006. *Plant Physiology*. Sinauer Associates, Inc, Publishers, Sunderland, Massachusetts, USA.

PP 508 PHYSIOLOGY OF PLANT MINERAL NUTRITION

(3L+1P) II

Objective

To impart knowledge about physiological and molecular aspects of mineral nutrition in plants.

Theory

UNIT I

History, definition and classification of mineral nutrients, mineral content of plant tissues. Pathway of nutrient movement from external solution into the roots. Structure and composition of membranes. Driving forces for the transport of nutrients across the membrane.

UNIT II

Characteristics of ion uptake by the roots. Interaction between the ions, radial transport across the roots, ion uptake along the roots, mechanisms of ion release into the xylem, xylem transport, phloem transport, nutrient cycling between shoots and roots, remobilization of mineral nutrients.

UNIT III

Uptake of gases through stomata, uptake of solutes, foliar application of mineral nutrients, leaching of mineral elements from leaves. Availability in soil/atmosphere and crop requirements, nutrient release and immobilization, nitrification and denitrification.

UNIT IV

Translocation and metabolic functions of macro and micro elements, optimum requirement, visible morphological and anatomical effects, cellular and sub-cellular effects, effect on metabolism, beneficial elements.

UNIT V

Growth and morphology of roots, architecture, allelopathy, variation in nutrient use efficiency and in nutrient requirements, nutrient toxicity response

UNIT VI

Ionomics and transporters, screening and selection techniques, molecular regulation and breeding for improved mineral ion transport/uptake and nutrient use efficiency.

Practicals

Diagnosis by visible symptoms, plant analysis, histochemical and biochemical methods, plant analysis vs. soil analysis, treatment of disorders, importance of root characteristics.

Suggested Readings

Barker, A.B. and Pilbeam, D.J. 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.

Mengel, K. and Kirkby, E.A. 2001. Dordrecht: Kluwer Academic Publishers. 849 pp.

Wallace, T. 2007. *The Diagnosis of Mineral Deficiencies in Plants by Visual Symptoms : A Colour Atlas and Guide*. Eastern Book Cooperation Delhi pp. viii+112.

Objective

To impart knowledge of physiological aspects of different crop plants.

Theory

UNIT I

Origin, evolution and distribution of crop, adaptability of crop to different agro climatic conditions (specific case studies of important cereal crops like wheat, rice, barley, maize, sorghum and minor millets).

UNIT II

Crop characteristics-growth and development (both vegetative and reproductive), physiological processes governing productivity

UNIT III

Influence of climatological factors (water, temperature, photoperiod and light) on crop growth attributes and physiological processes.

UNIT IV

Special problems of each crop, crop ideotype concept and source sink relationship.

Suggested Readings

Gardner, F.P., Pearce, R.B. and Mitchell, R.L. 1988. *Physiology of Crop Plants*. Scientific Publ.

Pessaraki, M. 2002. *Handbook of Plant and Crop Physiology*. Marcel and Dekker Inc. New York.

Satorre, E.H. and Slafer, G.A. (Eds) 1999. *Wheat: Ecology and Physiology of yield determination*. Food Product Press, New York.

PP 601 TECHNIQUES IN PLANT PHYSIOLOGY-I**(1L+2P) I****Objective**

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

Practicals

Measurement of osmotic potential, water potential, relative water content, principles of psychrometry and pressure chamber, measurement of transpiration, photosynthesis by infra red gas analyzer, A/Ci curves, respiration, light interception, ion leakage, effect of ABA on stomatal conductance, isolation and separation of photosynthetic pigments, principles of spectrophotometry and colorimetry, determination of the stomatal index of the leaf, basic methods pertaining to plant growth analysis, estimation of amino acids, proteins, sugars, oil content, ion leakage, estimation of nitrate content, activities of nitrate reductase and glutamine synthetase, effect of water potential and temperature on seed germination.

Suggested Readings

Coombs, J., Hall, D.O., Long, S.P. and Scurlock, J.M.O. (Eds.) 1987. *Techniques in bioproductivity and photosynthesis*. Pergamon Press.

Thimmaiah, S.R. 1999. *Standard methods of biochemical analysis*. Kalyani Publishers.

Objective

To apprise the students regarding abiotic stress to plant and its physiological and 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 stress: Physiological, biochemical and molecular mechanism, strategies to alleviate drought stress, signal transduction mechanism, Drought in relation to MAS and QTL, Role of ROS/antioxidants, ABA, Cytokinin and other hormones.

UNIT III

Temperature stress (high and low): Tolerance mechanisms-role of membrane lipids in temperature tolerance. Functions of regulatory proteins.

UNIT IV

Salinity stress: 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 V

Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of phytochelatin (heavy metal binding proteins).

Practicals

Determination of water status of plants: RWC, pressure chamber and psychrometry, determination of osmotic potential by osmometer, stomatal conductance, canopy temperature by infra-red thermometer, creation of nutrient deficiency and assessment of root characteristics, chlorophyll content index by chlorophyll meter, root biomass by root capacitance meter, heat tolerance and membrane integrity.

Suggested Readings

- Andrew, M.A. and Wood, J. Eds Jenks 2010. *Genes for plant abiotic stress*. Wiley-Blackwell Publication.
- Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. *Biochemistry and Molecular Biology of Plants*. Am, Soc. Plant Physiologists, Rockville, Maryland.
- Hirt, H., Shinozaki, K. Hirt, Heribert 2004. *Plant responses to abiotic stress*. Springer Berlin Heidelberg Publication.
- Hopkins, W.G. and Huner, N.P.A. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.
- Khan, N.A. and Singh, Sarvajeet 2008. *Abiotic stress and plant responses*. I.K. Publication.
- Parikh, A., Sopory, S.K. and Bohnert, H.J. 2010. *Abiotic stress adaptation in plants: Physiological, molecular and genomic foundation*. Springer Publication.
- Taize, L. and Zeiger, E. 2006. *Plant Physiology*. Sinauer Associates, Inc, Publishers, Sunderland, Massachusetts, USA.

Objective

To impart knowledge cell structure and function and physiological aspects of nitrogen metabolism, respiration, lipids, enzymes and secondary metabolites in plants.

Theory

UNIT I

Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell organelles, i.e. mitochondria, chloroplast, microbodies, vacuole, nucleus, ER; cell membrane structure and function. Protein trafficking and import into organelles.

UNIT II

Nitrogen fixation, nitrate reduction and ammonia assimilation, amino acids and ureides biosynthesis.

UNIT III

Fatty acid and lipid biosynthesis and degradation in membranes, plastids and endoplasmic reticulum.

UNIT IV

Respiration- energetics of respiration, formation of ATP and reducing power in the light, photophosphorylation, anabolic and catabolic role of citric acid cycle, respiration of lipids, proteins, carbohydrates and amino acids, physiological function of alternate pathway, dark respiration in green cells, fermentation.

UNIT V

Enzymes definition and classification, enzyme kinetics. Secondary metabolites-terpenes, phenols and alkaloids.

Suggested Readings

Buchanan, B.B., Gruissem, W. and Jones, R.L. 2000. *Biochemistry and Molecular Biology of Plants*. Am, Soc. Plant Physiologists, Rockville, Maryland.

Hopkins, W.G. and Huner, N.P.A. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury, F.B. and Ross, C.W. 1986. *Plant Physiology*, CBS Publishers & Distributors, New Delhi.

Taize, L. and Zeiger, E. 2006. *Plant Physiology*. Sinauer Associates, Inc, Publishers, Sunderland, Massachusetts, USA.

PP 604 TECHNIQUES IN PLANT PHYSIOLOGY- II (1L+3P) III**Objective**

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

Practicals

Enzyme estimation and purification procedure, principal and operation of spectrophotometer, infra red gas analyzer, chlorophyll fluorescence, use of stable and radio isotopes, gas chromatography, high pressure liquid chromatography, nitrogen estimation by kjeldhal method, micronutrient estimation by AAS, gel electrophoresis, western blotting, in vitro culture techniques, isolation of genomic and plasmid DNA, isolation and quantification of RNA, PCR and RT-PCR techniques and concept of phytotron.

Suggested Readings

- Coombs, J., Hall, D.O., Long, S.P. and Scurlock, J.M.O. (Eds.) 1987. Techniques in bioproductivity and photosynthesis. Pergamon Press.
- Thimmaiah, S.R. 1999. Standard methods of biochemical analysis. Kalyani Publishers.
- Sambrook, J., Fritsch, E.F. and Maniatis, T. 1989. Molecular Cloning: A Laboratory Manual Vol. I, II and III. Cold Spring Harbor Laboratory Press, USA.

PP 605 PLANT METABOLISM

(3L+0P) III

Objective

To impart advance knowledge of carbohydrate, lipid, and nitrogen metabolism.

Theory

UNIT I

Biosynthesis and degradation of hexose phosphate, biosynthesis of sucrose and its utilization, translocation, breakdown and storage, respiratory metabolism, glycolate pathway, pentose phosphate pathway, localization and evidence for its operation.

UNIT II

Starch synthesis, accumulation and breakdown in seeds during germination and in leaves, regulation of starch metabolism. Organic acid synthesis and its regulation, crassulacean acid metabolism and its regulation.

UNIT III

Classification of lipids and fatty acids - major, minor and unusual fatty acids. Fatty acids synthesis, chain elongation and unsaturated fatty acid biosynthesis. Lipid biosynthesis - triglycerides, phospho lipids, glycol lipids. Membrane lipid structure and function. Fat metabolism during germination and seed development- Beta oxidation, glyoxylate cycle, alpha oxidation.

UNIT IV

Nitrogen cycle, nitrogen fixation, nitrification and denitrification, nitrate and ammonia assimilation and regulation, transamination, amino acid synthesis, non-protein amino acids synthesis, nitrogen redistribution in cell, nitrogen inter conversion and transport during plant development, nodule metabolism, protein synthesis and its metabolism, sulphur metabolism. Biosynthesis and breakdown of nucleic acids.

Suggested Readings

- Salisbury, F.B. and Ross, C.W. 1986. *Plant Physiology*, CBS Publishers & Distributors, New Delhi.
- Taize, L. and Zeiger, E. 2006. *Plant Physiology*. Sinauer Associates, Inc, Publishers, Sunderland, Massachusetts, USA.
- Johnathan A. Napier 2007. *The production of unusual fatty acids in transgenic plants. Annu. Rev. Plant Biol.* 58: 295-319
- John B. Ohlrogge. 1994. *Design of new plant products: engineering of fatty acid metabolism. Plant Physiol.*104: 821-826.
- Hirschi, K.D. 2009. Nutrient biofortification of food crops. *Annu. Review of Nutrition.* 29: 401-421.

PP 607/AG 607 PHYSIOLOGY AND BIOCHEMISTRY OF HERBICIDE ACTION (3L + 1P) III

Objective

To provide the students up-to-date knowledge on herbicide physiology and biochemistry and recent approaches in weed management including biotechnological methods.

Theory

UNIT I

Weed biology and ecology; allelopathy and allelochemicals; management options; weed economic thresholds; use of models for improved competition studies.

UNIT II

Recent concepts on entry, uptake, translocation and metabolism of soil and foliar applied herbicides, and impact of environmental and plant factors.

UNIT III

Physiological, biochemical and molecular mechanism of action of different groups of herbicides. Metabolic pathway of herbicide degradation in plants and soil.

UNIT IV

Selectivity of herbicides - physiological and molecular mechanism; herbicide non-target toxicity. Herbicide residue and its management in cropping systems.

UNIT V

Herbicide resistance in weeds. Site-specific weed management. Advances in herbicide formulations; adjuvants and their classification. Herbicide mixtures and interactions. Remote sensing and GIS applications in weed science.

UNIT VI

Herbicide resistant crops - prospects, molecular and tissue culture approaches for development of herbicide resistant crops.

List of Practicals

Adjuvants and their effect on spray droplets, chemical entry and transport in the plants. Determination of effect of herbicides on physiological and biochemical processes like photosynthesis, respiration, membrane permeability. Quantification of pigment levels in leaves as affected by herbicides. Estimation of specific enzyme activities affected by herbicides. Demonstration of herbicides translocation by radio labeling techniques. Bioassay technique for analysis of herbicide residues. Allelopathic effects of plants. Evaluation of bio-efficacy and selectivity of herbicides.

Suggested Readings

Akobundu, I.O. 1987. *Weed Science in the Tropics : Principles and Practices*. John Wiley & Sons. Chichester, 522 p.

Andrew Cobb and Kirkwood, R.C. 2001. *Herbicides and Their Mechanisms of Action*, Blackwell.

Andrew Cobb 1991. *Herbicides and Plant Physiology*, Chapman and Hall Publishers.

Ashton, F.M. and Crafts, A.S. 1981. *Mode of Action of Herbicides*. 2nd Edn., Wiley-Interscience, 524 p.

Das, T.K. 2008. *Weed Science – Basics and Applications*. Jain Brothers, New Delhi, 901 p.

- Devine, M.D., Duke, S.O. and Fedtke, C. 1993. *Physiology of Herbicide Action*. PTR Prentice Hall, Englewood Cliffs, New Jersey, 441 p.
- Gupta, O.P. 1998. *Modern Weed Management*. AgroBotanica, Bikaner, 488 p.
- Jayakumar, R. and Jagannathan, R. 2003. *Weed Science Principles*. Kalyani Publishers, Ludhiana.
- Klingman, G.C. 1981. *Weed Science: Principles and Practices*. John Wiley and sons Inc., New York, 449 p.
- Monaco, T.J., Weller, S.C. and Ashton, F.M. 2002. *Weed Science - Principles and Practices*. Wiley.com Publ.
- Rao, V.S. 2000. *Principles of Weed Science*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 555 p.
- Stephen B. Powles and Qin, Yu. 2010. Evolution inaction: Plant resistant to herbicides. *Ann. Review Plant Biol.* 61, 317-347.
- Swarbrick, J.T. and Mercado, B.L. 1987. *Weed Science and Weed Control in South-east Asia*. FAO Plant Production and Protection Paper 81, Rome, Italy, 203 p.
- Walia, U.S. 2003. *Weed Management*. Kalyani Publishers, Ludhiana.
- Zimdahl, R.L. 1999. *Fundamentals of Weed Science*. 2nd edn., Academic Press, 556 p.

PP 608/SST 608 PHYSIOLOGY OF SEEDS

(2L+1P) III

Objective

To apprise students regarding seed germination, dormancy, physiological processes involved in regulation of seed development and physiological processes governing seed quality and its survival.

Theory

UNIT I

Introduction, importance of seeds, seed structure and function, chemical composition of seeds, seed development and maturation - physiological and molecular aspects; hormonal regulation of seed development, desiccation tolerance and sensitivity in relation to seed longevity, LEA protein.

UNIT II

Physiological and biochemical changes during seed maturation, assimilate movement to seeds, storage of carbohydrates, proteins and fats in seeds and biosynthesis.

UNIT III

Seed germination, factors influencing, breakdown and mobilization of stored products, carbohydrates, fat, protein, respiration and pathways of interconversion, control processes in the mobilization of food reserves, hormonal control of germination.

Seed dormancy, different types, environmental influences, mechanisms and control including phytochrome, method for breaking seed dormancy.

UNIT IV

Factors influencing loss of seed viability during storage, physiological and biochemical changes associated with seed ageing, theories of seed ageing, seed viability and its evaluation, seed storage, protection from water, temperature and contaminants, desiccation tolerance and sensitivity in relation to seed longevity.

UNIT V

Seed vigour, concept, importance, measurement; seed invigoration, methods, physiological and molecular basis of seed invigoration, effect of vigour on field emergence and yield, seed hardening.

Practicals

Chemical composition of seeds, testing seed vigour and viability, breaking of seed dormancy and germination, seed invigoration and priming treatments, accelerated ageing treatments, seed imbibition and leakage, enzyme activities during germination, sink ability of ovules, seed respiration.

Suggested Readings

- Agrawal, P.K. and Dadlani, M. 1992. *Techniques in Seed Science and Technology*, South Asian Publishers, Delhi.
- Amarjit S. Basra 2006. *Handbook of Seed Science and Technology*, Food Product Press, N.Y.
- Baskin, C.C. and Baskin J.M. 1998. *Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination*. Academic Press.
- Bench Arnold, L.R. and Rodolfo, A. Sanchez 2004. *Handbook of Seed Physiology*, Food Product Press, NY.
- Bewley, J.D. and Black, M. 1985. *Seed Physiology of Development and Germination*. Plenum Publishers
- Bewley, J.D. and Black, M. 1982. *Physiology and Biochemistry of seeds in relation to germination*, Vol. I & II, Springer Verlag, Berlin Heidelberg, New York.
- Copeland, L.O. and McDonald, M.B. 1995. *Principles of Seed Sciences and Technology*. Burgers Publ. Co.
- David R. Murray 1984. *Seed Physiology* Vol. I & II, Academic Press, NY.
- Khan, A.A. 1977. *Physiology and biochemistry of seed dormancy and germination*, North Holland Co. Amsterdam, New York.
- Kigel, J. and Galili, G. 1995. *Seed Development and Germination*. Marcel Dekker, NY.
- Sadasivam, S. and Manickam, A. 1996. *Biochemical Methods* 2nd ed. New Age International Publishers, New Delhi
- Srivastav, L.M. 2000. *Plant Growth and Development - Hormones and Environment*, Academic Press.
- Singhal, N.C. 2009. *Seed Science and Technology*, Kalyani Publishers

PP 617/PHT 617 PHYSIOLOGY OF RIPENING AND SENESCENCE

(2L+1P) III

Objective

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

Theory

UNIT I

Environmental factors influencing senescence, ripening and post harvest life of fruits, flowers and vegetables.

UNIT II

Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening. Senescence associated genes and gene products.

UNIT III

Functional and ultra structural changes in chloroplast membranes, mitochondria and cell wall during senescence and ripening.

UNIT IV

Ethylene biosynthesis, perception and molecular mechanism of action. Regulatory role of ethylene in senescence and ripening. Biotechnological approaches to manipulate ethylene biosynthesis and action.

UNIT V

Alternate post harvest methodology and quality attributes. Scope for genetic modification of post harvest life on flowers and fruits. Uses of GM crops and ecological risk assessment.

Practicals

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

Knee, M. 2002. *Fruit Quality and its Biological Basis*. Sheffield Academic Press, CRC Press.

Khan, N.A. 2006. *Ethylene action in plants*. Springer Verlag.

Davis, P.J. 2004. *Plant hormone: Biosynthesis, signal transduction and action*. Kluwer Academic Publishers.

Bartz, J.A. and Brecht, J.K. 2003. *Post harvest physiology and pathology of vegetables*. Marcel Dekker Inc.

Seymour, G., Taylor, J. and Tucker, G. 1993. *Biochemistry of fruit ripening*. Edited Chapman and Hall, London.

Valpuesta, V. 2002. *Fruit and vegetable biotechnology*. Woodhead Publishing Limited, Cambridge, England.

Dris, R. and Jain, S.M. 2004. *Production practices and quality assessment of food crops*, Vol. 4: Post harvest treatment and Technology. Kluwer Academic Publisher.

Paliyath, G., Murr, D.P., Handa, A.K. and Lurie, S. 2008. *Post harvest biology and technology of fruits, Vegetables and Flowers*. Blackwell Publishing, Iowa, USA.

Nooden, L.D. 2004. *Plant Cell Death Processes*. Elsevier Science, USA.

PP 621/ HORT 621 GROWTH AND DEVELOPMENT OF HORTICULTURAL CROPS (3+2)III

Objective

To teach about the growth and development processes of horticultural crops, knowledge of basic physiological and molecular processes affecting growth, flowering and production of quality produce.

Theory

UNIT I

Defining growth and development; physical and physiological aspects of growth, germination, juvenility, root and leaf differentiation,

UNIT II

Flowering, fruit set and development, fruit maturity and ripening, abscission, senescence of horticultural crops: Factors influencing flowering, photoperiodism vernalisation, effect of temperature, heat units, thermoperiodism.

UNIT III

Biosynthesis of auxins, gibberellins, cytokinins, abscisic acid, ethylene, brassino-steroids, synthetic growth inhibitors, morphactins, methyl jasmonates, salicylic acid, polyamines, etc. their mode of action.

UNIT IV

Role of plant growth promoters and inhibitors on physiological processes like seed and bud dormancy, fruit thinning, fruit drop, sex expression modification in cucurbits and induction of parthenocarpy; plastochrom,

UNIT V

Water relations, stress physiology in relation to drought, temperature and salts, quality improvement in fruits, vegetables and flowers.

Practicals

Visit to Physiology laboratory; Testing of seed germination and breaking dormancy in seeds; Study on fruit set and fruit growth. Estimation of tissue macro- and micro-nutrients; Estimation of enzymes; Estimation of chlorophyll, carotenoids and other pigments. Bioassay of plant hormones; Use of HPLC and GC for estimation of phyto-hormones; Application of GRs in fruit thinning and control of fruit drop; sex expression and induction of parthenocarpy in horticultural crops; Use of PGRs in ornamental crops. Light manipulation in protected cultivation.

Suggested Readings

Moore, T.C. *Biochemistry and physiology of plant hormone*.

Bleasdale, J.K.A. 1984. *Plant Physiology in Relation to Horticulture*. 2nd Ed. MacMillan & Co.

Krishnamurthy, H.N. 1993. *Physiology of Plant Growth and Development*. Atma Ram and Sons, Delhi.

Fosket, D.E. 1994. *Plant Growth and Development: a Molecular Approach*. Academic Press.

Leopold, A.C. and Kriedermann, P.E. 1985. *Plant Growth and Development*. 3rd Ed. Mc Graw-Hill. London.

Peter, K.V. 2008. (Ed.) *Basics of Horticulture*. New India Publ. Agency.

Roberts, J., Downs, S. and Parker, P. 2002. *Plant Growth Development*. In: Plants (I. Ridge, Ed.), pp. 221-274, Oxford University Press.

Salisbury, F.B. and Ross, C.W. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.

Noggle, Ray G. and Fritz, G. J. 1991. *Introductory Plant Physiology*. Prentice Hall of India Pvt. Ltd., New Delhi.

Taiz, L. and Zeiger, E. 2006. *Plant Physiology*. Publishers: Sinauer Associates, Inc., Massachusetts, USA.

Fosket, D.E. 1994. *Plant Growth and Development: a Molecular Approach*. Academic Press.

Nickell, L.G. 1983. *Plant Growth Regulating Chemicals*. CRC Press.