BIOCHEMISTY

BIOCHEM 501 : BASIC BIOCHEMISTRY 3+1

Objective

To provide elementary knowledge/overview of structure and functions and metabolism of biomolecules.

Theory

UNIT I

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers.

UNIT II

Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids.

UNIT III

Structure and biological functions of vitamins, enzymes classification and mechanism of action; regulation, factors affecting enzyme action. Hormones animal plants and insects, Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

UNIT IV

Metabolism of carbohydrates, photosynthesis and respiration, oxidative phosphorylation, lipids, proteins and nucleic acids. DNA replication, transcription and translation; recombinant DNA technology

Practical

Preparation of standard and buffer solutions, Extraction and estimation of sugars, Amino acids,Estimation of Proteins by Lowry's method,
Estimation of DNA and RNA by diphenylamine and orcinol methods
Estimation of Ascorbic acid, Separation of biomolecules by TLC and Paper chromatography.

Suggested Readings

- Conn EE & Stumpf PK. 1987. Outlines of Biochemistry. John Wiley.
- Metzler DE. 2006. Biochemistry. Vols. I, II. Wiley International.
- Nelson DL & Cox MM. 2004. Lehninger Principles of Biochemistry. 4th Ed. MacMillan.
- Voet D, Voet JG & Pratt CW. 2007. Fundamentals of Biochemistry. John Wiley.

BIOCHEM 502 : INTERMEDIARY METABOLISM 3+0

Objective

To teach metabolic pathways, their regulation and engineering, and methods used in their elucidation.

Theory

UNIT I

The living cell a unique chemical system, Introduction to metabolism, methods of studying metabolism, transport mechanism, bioenergetics, biological oxidation, signal transduction.

UNIT II

Catabolic and anabolic pathways of carbohydrates, lipids, regulation and their metabolic disorders. Energy transduction and oxidative phosphorylation.

UNIT III

General reactions of amino acid metabolism, Degradative and biosynthetic pathways of amino acids and their metabolic disorders. Sulphur metabolism, Metabolic engineering concepts.

UNIT IV

Compartmentation of metabolic pathways, metabolic profiles of major organs and regulation of metabolic pathways.

Suggested Readings

- Berg JM, Tymoczko JL, Stryer L&Clarke ND 2000. Biochemistry. 5th Ed. WH Freeman& Co.
- Metzler DE. 2006. Biochemistry. Vols. I, II. John Wiley.
- Voet D, Voet JG & Pratt CW. 2007. Fundamentals of Biochemistry. John Wiley.
- Zubey GL. 1998. Biochemistry. 4th Ed. WCB London.

BIOCHEM 503 : ENZYMOLOGY 2+1

Objective

To impart knowledge about the catalytic role of enzymes, their structure, physico-chemical, kinetic and regulatory properties and mechanism of action.

Theory

UNIT I

Introduction and historic perspective, Enzyme nomenclature and classification, enzyme compartmentalization in cell organelles, isolation and purification of enzymes, measurement of enzyme activity. ribozymes, isozymes, abzymes,

UNIT II

Enzyme structure, enzyme specificity, active site, active site mapping, mechanism of enzyme catalysis. cofactors, coenzymes- their structure and role.

UNIT III

Enzyme kinetics, enzyme inhibition and activation, multienzyme complexes, allosteric enzymes and their kinetics, regulation of enzyme activity.

UNIT IV

Isolation and purification of enzymes, Applications of enzymes in chemical and food industry, enzyme immobilization, biosensors and clinical applications of enzymes.

Practical

Enzyme assay by taking any model enzyme like alpha-amylase or acid phosphatase,isolation and purification of any model enzyme like alpha- amylase or acid phosphatase,study of the effect of enzyme and substrate concentrations and determination of Km and Vmax, determination of pH and temperature optima and effect of various inhibitors, determination of the pH and temperature stability of enzyme.

Suggested Readings

- Bergmeyer HU. 1983. Methods of Enzymatic Analysis. Vol. II. Verlag Chemie, Academic Press.
- Dixon M, Webb EC, Thorne CJR & Tipton KF. 1979. Enzymes. 3rd Ed. Longman.
- Maragoni AG. 2003. Enzyme Kinetics - A Modern Approach. John Wiley.
- Palmer T. 2001. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry. 5th Ed. Horwood Publ.
- Price NC & Stevens L. 2003. Fundamentals of Enzymology. Oxford Univ. Press.
- Wilson K & Walker J. (Eds.). 2000. Principles and Techniques of Practical Biochemistry. 5th Ed. Cambridge Univ. Press.

BIOCHEM 504 : MOLECULAR BIOLOGY 2+1

Objective

To provide knowledge regarding genes, their functions, expression, regulation and transfer in heterologous systems.

Theory

UNIT I

Historical development of molecular biology, nucleic acids as genetic material, chemistry and structure of DNA and RNA, Genome organization in prokaryotes and eukaryotes, chromatin structure and function.

UNIT II

DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase, repetitive and non-repetitive DNA, satellite DNA; transcription process, RNA editing, RNA processing.

UNIT III

Ribosomes structure and function, organization of ribosomal proteins and RNA genes, genetic code, aminoacyl tRNA synthases' inhibitors of replication, transcription and translation; translation and Post translational modification; nucleases and restriction enzymes, regulation of gene expression in prokaryotes and eukaryotes, molecular mechanism of mutation.

UNIT IV

DNA sequencing, recombinant DNA technology, vectors, isolation of genes, recombinants vector, selection of recombinants, PCR; general features of replication, transcription, site directed mutagenesis and translation in eukaryotes.

Practical

Isolation and purification of DNA and RNA from different sources, check of purity of isolated DNA and RNA, restriction fragmentation and separation of oligos by agarose electrophoresis, RAPD analysis of DNA, cDNA synthesis using PCR, Southern and Northern blotting experiments

Suggested Readings

- Adams RLP, Knowler JT & Leader DP. 1992. The Biochemistry of the Nucleic Acids. 11th Ed. Chapman & Hall.
- Alberts B, Bray D, Lewis J, Raff M, Roberts K & Watson JD 2006.Molecular Biology of the Cell. 6th Ed. Garland Publ.
- Blackburn GM & Gait MJ. 1996. Nucleic Acids in Chemistry and Biology.2nd Ed. Oxford University Press.
- Freifelder D & Malacinski GM. 1996. Essentials of Molecular Biology. 3rd Ed. Panima.
- Glick BR & Pasternak JJ. 1994. Molecular Biology: Principles and Applications of Recombinant DNA Technology. ASM Press.
- Lewin B. 2007. Genes IX. Oxford University Press.
- Lodish H, Berk A, Zipursky SA, Matsudaira P, Baltimore D & Darnell J.1999. Molecular Cell Biology. WH Freeman.
- Old RW & Primrose SB. 1989. Principles of Gene Manipulation: An Introduction to Genetic Engineering. 4th Ed. Blackwell Scientific Publ.
- Sambrook J & Russel DW. 2001. Molecular Cloning: A Laboratory Manual. Vols. I-III. Cold Spring Harbor.

BIOCHEM 505 : TECHNIQUES IN BIOCHEMISTRY 1+2

Objective

To impart practical knowledge about various techniques used in purification and characterization and estimation of cellular constituents.

Theory

UNIT I

Chromatographic and electrophoretic methods of separation, Principles and applications of Paper, Thin layer & HPTLC, Gas, Gas-liquid, Liquid chromatography, HPLC and FPLC; Paper and gel electrophoresis, Different variants of polyacrylamide gel electrophoresis (PAGE) like native and SDS-PAGE, 2D-PAGE, capillary electrophoresis.

UNIT II

Spectrophotometry: Principles and applications UV-Visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy.

UNIT III

Hydrodyanmic methods of separation of biomolecules such as viscosity and sedimentation-their principles, variants and applications.

UNIT IV

Tracer techniques in biology: Concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of α, β and γ emitters, scintillation counters, γ-ray spectrometers, autoradiography, applications of radioactive tracers in biology, principles and applications of phosphor imager.

Practical

Determination of absorption maxima of some important chemicals from their absorption spectra, estimation of biomolecule using spectrophotometer, Separation of carbohydrates and amino acids by paper chromatography, Separation of lipids by thin layer and column chromategraphy, Separation of proteins by ion exchange and gel filtration chromatography, Electrophoretic techniques to separate proteins and nucleic acids ,Centrifugation- Cell fractionation, Application of GLC,HPLC, FPLC in separation of biomolecules,Use of radioisotopes in metabolic studies.

Suggested Readings

- Clark JM. 1977. Experimental Biochemistry. 2nd Ed.
- WH Freeman. Sawhney SK & Singh R. 2000. Introductory Practical Biochemistry. 2nd Ed. Narosa.
- Willard M, Merritt LL & Dean JA.1981. Instrumental Methods of Analysis. 4th Ed. Van Nostrand.
- William BL & Wilson K. 1975. Principles and Techniques of Practical Biochemistry. Edward Arnold.
- Wilson K, Walker J & Walker JM. 2005. Principles and Techniques of Practical Biochemistry. Cambridge Univ. Press.

BIOCHEM 506 : IMMUNOCHEMISTRY 2+1

Objective

To give an insight into the biochemical basis of immunity.

Theory

UNIT I

History and scope of immunology, antigens, adjuvants, immune system, organs, tissues and cells, immunoglobulins, molecular organization of Immunoglobulin.

UNIT II

Classes of antibodies, Antibody diversity, theories of generation of antibody diversity, Vaccine, Monoclonal antibodies, polyclonal antibodies, Hybridoma, Recombinant antibodies, complement system- classical and alternate.

UNIT III

Cellular interactions in the immune response, major histocompatibility complex, cell mediated immune response, cytokines.

UNIT IV

Immunoregulation, immunological tolerance, hypersensitivity, mechanisms of immunity, innate resistance and specific immunity. Current immunological techniques-ELISA, RIA

Practical

Handling, inoculation and bleeding of laboratory animals, Preparation of antigens and antisera, natural antibodies, Carbon clearance test, lymphoid organs of the mouse, Morphology of the blood leucocytes, separation of lymphocytes from blood, viable lymphocyte count, Antigen-antibody interaction, precipitation, agglutination, direct and indirect haemagglutination, Immunoele-ctrophoresis, Complement fixation, Quantitation of immunoglobulins by zinc sulphate turbidity and single radial immunodiffusion.

Suggested Readings

- Abbas AK & Lichtman AH. 2003. Cellular and Molecular Immunology. 5th Ed. WB Saunders.
- Goldsby RA, Kindt TJ & Osborne BA. 2003. Immunology. 4th Ed. WH Freeman.
- Harlow & Lane D. (Eds.) 1988. Antibodies: A Laboratory Manual. Cold Spring Harbor Laboratory.
- Kuby J. 1996. Immunology. 3rd Ed. WH Freeman.
- Male D, Brostoff J, Roth DB & Roitt I. 2006. Immunology. 7th Ed. Elsevier.

BIOCHEM 507 : PLANT BIOCHEMISTRY 3+0

Objective

Detailed information about biochemical and molecular basis of various plant processes and plant growth regulatory substances.

Theory

UNIT I

Scope and importance of biochemistry in Agriculture, Plant cell organelles and their separation, structure and function of cell organelle. Photosynthetic pigments in relation to their functions, photosynthesis, C_3, C_4 and CAM pathways, photorespiration.

UNIT II

Sucrose-starch interconversion, biosynthesis of structural carbohydrates, storage proteins and lipids. Biochemistry of nitrogen fixation and nitrate assimilation, sulphate reduction and incorporation of sulphur in to amino acids.

UNIT III

Biochemistry of seed germination and development, Biochemistry of fruit ripening, phytohormones and their mode of action, signal transduction.

UNIT IV

Biochemistry and significance of secondary metabolites-cyanogenic glycosides, glucosinolates, phenolic compounds, terpenoids, alkaloids, plant defense system.

Suggested Readings

- Buchanan BB, Gruissem W & Jones RL. 2000. Biochemistry and Molecular Biology of Plants. 2nd Ed. John Wiley.
- Dey PM & Harborne JB. 1997. Plant Biochemistry. Academic Press.
- Goodwin TW & Mercer EI. 1983. Introduction to Plant Biochemistry. Pergamon Press.
- Heldt HS. 1997. Plant Biochemistry and Molecular Biology. Oxford Univ. Press.
- Lea PJ & Leegood RC. 1993. Plant Biochemistry and Molecular Biology. 2nd Ed. John Wiley.

BIOCHEM 508 : ANIMAL BIOCHEMISTRY 3+0

Objective

To impart knowledge regarding biochemistry of various physiological processes, specialized tissues and hormone action in animal system.

Theory

UNIT I

Digestion and absorption of food, Vitamins,, Detoxification, biochemistry of specialized tissues – connective tissue, skin, muscle, nervous tissue and blood and other body fluids.

UNIT II

Water, electrolyte and acid-base balance, biochemistry of respiration, structure, function and mechanism of major trace elements.

UNIT III

Hormones of thyroid, hypothalamus, pituitary, pancreas, adrenals and sex hormones, Membrane receptors of hormones, signal transduction, biochemistry of reproduction.

UNIT IV

Immune systems, immunoglobulins, monoclonal antibodies, formation of antibody, antibody diversity, complement system – classical and alternate, major histocompatibility complexes, cell mediated immune response, mechanisms of immunity.

Suggested Readings

- Devlin TM. 2006. Text Book of Biochemistry with Clinical Correlations. 6th Ed. John Wiley.
- Goldsby RA, Kindt TJ, Kuby J & Osborne BA. 2003. Immunology. 4th Ed. WH Freeman. & Co.
- Harper H. A. 2000. Physiological Chemistry. MacMillan.
- Buchanan BB, Gruissem W & Jones RL. 2000. Biochemistry and Molecular Biology of Plants. 2nd Ed. John Wiley.

BIOCHEM 509 : FOOD AND NUTRITIONAL BIOCHEMISTRY 2+1

Objective

To impart knowledge regarding the biochemical aspects of various nutrients and their interactions in foods during processing, storage and deterioration.

Theory

UNIT I

Fundamentals of humam nutrition, concept of balanced diet, biochemical composition, energy and food value of various food grains (including cereals, pulses, oilseeds), fruits and vegetables. Physico-chemical, functional and nutritional characteristics of carbohydrates, proteins and fats and their interactions (emulsions, gelation, browning etc.).

UNIT II

Biochemical and nutritional aspects of vitamins, minerals Nutraceuticals, antinutritional factors, biochemistry of post harvest storage.

UNIT III

Effect of cooking, processing and preservation of different food products on nutrients, biochemical aspects of food spoilage, role of lipase and lipoxygenase, oxidative rancidity and antioxidants.

UNIT IV

Enzymes in food industry, food additives (coloring agents, preservatives etc.), biogenesis of food flavours and aroma, nutritional quality of plant, dairy, poultry and marine products.

Practical

Estimation of starch, lipid/oil, phenols in plant tissue/sample, Estimation of carotenoids, Estimation of Trypsin and chymotrypsin inhibitor activities in seeds, Estimation of Vitamin C in fruits,Reducing & non reducing sugar in fruits, Estimation of protein contents, Estimation of dietary fibre, Determination of limiting amino acids, Estimation of Phytate/Oxalate.

Suggested Readings

- Alais C & Lindel G. 1995. Food Biochemistry. Amazon Springer.
- DeMan JM. 1999. Principles of Food Chemistry. 3rd Ed. Springer.
- Fennema OR. 1996. Food Chemistry. 3rd Ed. CRC Press.
- Hulme AC. (Ed.). 1970. Biochemistry of Fruits and Vegetables and their Products. Vols. I, II. Academic Press.
- Ranganna S. (Ed.). 1986. Handbook of Analysis and Quality for Fruits and Vegetable Products. Tata McGraw Hill.
- Robinson DS. 1987. Food Biochemistry and Nutritional Value. Longman.

BIOCHEM 510 : CARBON AND NITROGEN METABOLISM 2+1

Objective

To impart knowledge of general carbon and nitrogen metabolism in plants with special reference to starch and cell wall polysaccharides and biological nitrogen fixation and assimilatory pathways.

Theory

UNIT I

Carbon metabolism: Synthesis of sucrose, Regulation of sucrose phosphate synthesis, Transport of sucrose, phloem loading and unloading, synthesis of starch in leaves and seeds, concept of transitory starch.

UNIT II

Synthesis of fructose, galactomannans raffinose series oligosaccharides and trehalose.

UNIT III

Nitrogen cycle- Biochemistry of nitrate assimilation and its regulation, GS/GOGAT and GDH pathway, ureides and amides as nitrogen transport compounds, chemoautotrophy in denitrifying bacteria.

UNIT IV

Biological nitrogen fixation; structure function and regulation of nitrogenase; nif genes and their regulation; biochemical basis of legume- Rhizobium symbiosis, genes involved in synthesis.

Practical

Estimation of nitrite content, Estimation of protein by Lowry's method, Estimation of starch, Estimation of nitrate content by hydrazine sulphate reduction method, i*n vivo* assay of nitrate reductase activity, *in vitro* assay of nitrate reductase activity, *in vitro* assay of nitrite reductase activity, *in vitro* assay of glutamine synthetase activity, *in vitro* assay of glutamate synthase and glutamate dehydrogenase activity, Estimation of ureides and amides, Assay of

nitrogenase activity by acetylene reduction method, Estimation of hydrogen evolution by legume nodules.

Suggested Readings

- Beevers L. 1979. Nitrogen Metabolism in Plants. Gulab Vazirani for Arnold-Heinermann.
- Bergersen FJ. (Ed.). 1980. Methods for Evaluating Biological Nitrogen Fixation. John Wiley & Sons.
- Bray CM. 1983. Nitrogen Metabolism in Plants. Longman.
- Buchanan BB, Gruissem W & James RL. (Eds.). 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists.
- Mehta SL, Lodha ML & Sane PV. (Eds.). 1993. Recent Advances in Plant Biochemistry. ICAR.

BIOCHEM 601 : BIOCHEMISTRY OF CEREALS, OILSEEDS AND PULSES 2+0

Theory

Biochemical changes during germination, development and maturation of cereals, oilseeds and pulses, Chemical composition and nutritive values of cereals (rice, wheat, maize, sorghum and bajra), oilseeds (groundnut, cotton seed, castor, sesamum rape and mustard) and pulses crop (bengal gram, pigeonpea). Phytotoxin, aflatoxins, gossypol, naturally occurring protenase inhibitors and other plant toxins. Chemical changes and nutritional deterioration in infested cereals, oilseeds and pulses crop. Prospect of genetic upgrading of grain quality.

Practical

Proximate analysis, essential amino acids fatty acids profile, antinutritional factors, biochemical changes during seed development and germination.

BIOCHEM 601 : ADVANCED ENZYMOLOGY 2+0

Objective

To provide advanced knowledge about the structure, mechanism, kinetics and regulation of enzymes and their use as biosensors.

Theory

UNIT I

Theory of enzymatic catalysis, specificity, concept of active site and enzyme substrate complex, active site mapping, acid-base and covalent catalysis, factors associated with catalytic efficiency, proximity and orientation, distortion and strain, induced fit hypothesis, Mechanism of enzyme reactions.

UNIT II

Effect of different factors affecting enzyme activity, transition state theory, Arrhenius equation, Determination of energy of activation, kinetics of pH and temperature and determination of pKa and ΔH of active site amino acids.

UNIT III

Kinetics of bisubstrate reactions, mechanism determination by radioisotope exchange, kinetics of mixed inhibitions, substrate and product inhibition.

UNIT IV

Role of enzymes in regulation of metabolism, allosteric enzymes and their kinetics, enzyme engineering, Bifunctional enzymes, enzyme engineering,

Suggested Readings

- Dixon M & Web EC. 1979. Enzymes. 3rd Ed. Longmans Green. Seigel IH. 1975. Enzyme Kinetics. John Wiley.

BIOCHEM 602 : ADVANCED MOLECULAR BIOLOGY 3+0

Objective

To impart latest information on the molecular biochemistry of isolation, transfer and expression of genes in plants and biochemical approaches employed in gene therapy.

Theory

UNIT I

Organization of prokaryotic genome, nuclear and organelle genes, concept of genome mapping, molecular evolution, cell development and differentiation.

UNIT II

Prokaryotic and eukaryotic gene regulation, RNA editing, molecular biology of viruses.

UNIT III

Methods of gene isolation and transfer in plants and animals, molecular basis of male sterility, Application of genetic engineering in different fields.

UNIT IV

Site directed mutagenesis, gene targeting and gene therapy, bioethics and biosafety guidelines and IPR in recombinant DNA research.

Suggested Readings

- Alberts B, Bray D, Lewis J, Raff M, Roberts K & Watson JD. 2006.
- Molecular Biology of the Cell. 6th Ed. Garland Publ. Lewin B. 2007. Gene IX. 9th Ed. Pearson Publ.
- Selected articles from journals.

BIOCHEM 603 : BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES 3+0

Objective

To impart latest development about biochemistry of biotic and abiotic stresses in plants.

Theory

UNIT I

Plant-pathogen interaction and disease development; molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.

UNIT II

Plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance.

UNIT III

Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids, pathogen-derived resistance.

UNIT IV

Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants, synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation.

UNIT V

Reactive oxygen species and biotic and abiotic stress, antioxidants, enzymes defense system. Role of calcium, nitric oxide and salicylic acid in plant development. Molecular strategies for imparting tolerance against biotic and abiotic stress.

Suggested Readings

- Basra AS. 1997. Stress Induced Gene Expression in Plants. Harwood Academic Publ.
- Chessin M, DeBorde D & Zipf A. 1995. Antiviral Proteins in Higher Plants. CRC Press.
- Crute IR, Burdon JJ & Holub EB. (Eds.). 1997. Gene-for-Gene Relationship in Host-Parasite Interactions. CABI.

BIOCHEM 604 : CURRENT TOPICS IN BIOCHEMISTRY 1+0

Objective

To acquaint the students with the advanced developments in the field of biochemistry and to inculcate the habit of searching and reading the topics of current importance.

Theory

UNIT I

Advanced topics related to Nutrition and metabolism.

UNIT II

Advanced topics related to enzymology and industrial biochemistry.

UNIT III

Advanced topics related to molecular biochemistry and immunology.

UNIT IV

Advanced topics related to metabolic engineering and bioprospecting.

Suggested Readings

- Selected articles from journals.

BIOCHEM 605 : GENOMICS, PROTEOMICS AND METABOLOMICS 3+0

Objective

To impart knowledge in the upcoming areas of biochemistry. and to acquaint the students with the recent developments of job opportunities in pharmaceutical and other industries.

Theory

UNIT I

Protein and nucleic acid sequencing: Various methods of sequencing including automated sequencing and microarrays, whole genome sequence analysis.

UNIT II

Comparative genomics, functional genomics, transcriptomics, gene identification, gene annotation, pairwise and multiple alignments, application of genomics, Quantitative PCR, SAGE, MPSS, microarray.

UNIT III

Proteome technology- 2D-PAGE, MSMS, MALDI-TOF, protein microarray, comparative proteomics and structural proteomics.

UNIT IV

Metabolic pathway engineering, vitamin A engineering in cereals, micro- array analysis, role of bioinformatics in functional genomics.

Suggested Readings

- Baxevanis AD & Ouellette BFF. 2004. Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins. 3rd Ed. Wiley InterScience.
- Dale JW & Schantz MV. 2002. From Genes to Genomes. John Wiley.
- Lieber DC. 2002. Introduction to Proteomics - Tools for the New Biology. Humana Press.
- Suhai S. 2002. Genomics and Proteomics - Functional and Computational Aspects. Kluwer.

BIOCHEM 606 : BIOMEMBRANES 2+0

Objective

To teach structure and functions of biomembranes, structure-function relationships, membrane biogenesis.

Theory

UNIT I

Concept of biomembranes and their classification based on cellular organelles; physico-chemical properties of different biological and artificial membranes, cell surface receptors and antigen.

UNIT II

Membrane biogenesis and differentiation; membrane components-lipids, their distribution and organization; proteins, intrinsic and extrinsic, their arrangement; carbohydrates in membranes and their function.

UNIT III

Various membrane movements; transport across membrane and energy transduction.

UNIT IV

Role of membrane in cellular metabolism, cell recognition and cell –to – cell interaction; signal transduction, recent trends and tools in membrane research.

Suggested Readings

- Lodish H, Berk A, Zipursky SA, Matsudaira P, Baltimore D & Darnel J. 1999. Molecular Cell Biology. WH Freeman.
- Nelson DL & Cox MM. 2000. Lehninger Principles of Biochemistry. 3rd Ed. Printed in India by Replika Press Pvt. Ltd., New Delhi for Worth Publ., New York.
- Smallwood M, Knox JP & Bowls BJ. 1996. Membranes: Specialized Functions in Plants. Bros. Scientific Publ.

BIOCHEM 607 : ADVANCED TECHNIQUES IN BIOCHEMISTRY 0+2

Objective

To impart students a hands on training of techniques of biochemistry and molecular biology.

Theory

UNIT I

Isolation and purification of protein from microbial/plant/animal source. Electrophoretic separation of protein. Determination of molecular weight of protein using PAGE/ gel filtration method.

UNIT II

Experiments on DNA: Isolation, agarose gel electrophoresis and restriction analysis of DNA.

UNIT III

Isolation of chloroplast and mitochondria by differential centrifugation and their purification by density gradient centrifugation.

UNIT IV

Isolation and purification of enzymes, isozymic analysis and enzyme immobilization

Suggested Readings

- Kolowick NP & Kaplan NP. Methods in Enzymology. Academic Press (Series).
- Plummer DT. 1998. An Introduction to Practical Biochemistry. 3rd Ed. Tata McGraw Hill.
- Rickwood D. (Ed.). 1984. Practical Approaches in Biochemistry. 2nd Ed. IRL Press, Washington DC.
- Wilson K & Goulding KH. 1992. A Biologist's Guide to Principles and Techniques of Practical Biochemistry. 3rd Ed. Cambridge Univ. Press.
- Wilson K & Walker J. 2000. Principles and Techniques of Practical Biochemistry. 5th Ed. Cambridge Univ. Press.

MICROBIOLOGY

MICRO 501 : PRINCIPLES OF MICROBIOLOGY 3+1

Objective

To teach the students about basics in development of microbiology, differences in prokaryotes and eukaryotic cell and classification of prokaryotes.

Theory

UNIT I

Development of Microbiology in the 18^{th} and 19^{th} century. Morphology, structure and function of prokaryotic and eukaryotic cell. Archea. Classification of prokaryotes – Basic principles and techniques used in
bacterial classification.

UNIT II

Evolutionary relationship among prokaryotes. Phylogenetic and numerical taxonomy. Use of DNA and r-RNA sequencing in classifications.

UNIT III

Study of major groups of bacteria belonging to Gracilicutes, Firmicutes, Tanericutes and Mendosicutes.

UNIT IV

Viruses – morphology, classification and replication of plant, animal and bacterial viruses. Cultivation methods of viruses. Immune response – specific and non-specific resistance. Normal microflora of human body; some common bacterial and viral diseases of humans and animals.

Practical

Methods of isolation, purification and maintenance of microorganisms from different environments (air, water, soil, milk and food). Enrichment culture technique – isolation of asymbiotic, symbiotic nitrogen fixing bacteria. Isolation of photosynthetic bacteria. Use of selective media, antibiotic resistance and isolation of antibiotic producing microorganisms. Morphological, physiological andbiochemical characterization of bacteria.

Suggested Readings

- Brock TD. 1961. Milestones in Microbiology. Infinity Books.
- Pelczar MJ, Chan ECS & Kreig NR. 1997. Microbiology: Concepts and Application. Tata McGraw Hill.
- Stainier RY, Ingraham JL, Wheelis ML & Painter PR. 2003. General Microbiology. MacMillan.
- Tauro P, Kapoor KK & Yadav KS. 1996. Introduction to Microbiology. Wiley Eastern.

MICRO 502 : MICROBIAL PHYSIOLOGY AND METABOLISM 3+1
(Pre-requisite Micro 401, Micro 501)

Objective

To teach students about cell cycle, growth and practical training on methods to determine microbial growth.

Theory

UNIT I

Structure, function, biosynthesis and assembly of various cellular components of prokaryotes. Archea and fungi. Transport of solutes across the membrane.

UNIT II

Microbial growth. Cell cycle and cell division. EMP, HMP, ED, TCA pathways, Aerobic and anaerobic respiration. Fermentative metabolism. Biosynthesis of macromolecules. Regulation of microbial metabolism.

UNIT III

Effect of chemicals and other environmental factors on growth.Morphogenesis and cellular differentiation.

UNIT IV

Important metabolic patterns in photoautotrophs, photoheterotrophs, chemoautotrophs and chemoheterotrophs.

Practical

Use of simple techniques in laboratory (Colorimetry, Centrifugation, Electrophoresis and GLC). Determination of viable and total number of cells. Measurement of cell size. Gross cellular composition of microbial cell. Growth – Factors affecting growth. Sporulation and spore germination in bacteria. Protoplasts formation. Induction and repression of enzymes.

Suggested Readings

- Doelle HW. 1969. Bacterial Metabolism. Academic Press.
- Gottschalk G. 1979. Bacterial Metabolism. Springer Verlag. Moat AG. 1979. Microbial Physiology. John Wiley & Sons.
- Sokatch JR. 1969. Bacterial Physiology and Metabolism. Academic Press.

MICRO 503 : MICROBIAL GENETICS 2+1
(Pre-requisite Micro 401, Micro 501)

Objective

To acquaint the learners regarding molecular concepts of bacteria and viruses and impact of gene cloning on human welfare.

Theory

UNIT I

Prokaryotic, eukaryotic and viral genome. Replication of Eukaryotic, Prokaryotic and Viral DNA. Structure, classification and replication of plasmids.

UNIT II

Molecular basis of mutation. Biochemical genetics and gene mapping by recombination and complementation. Fine gene structure analysis. Fungal genetics.

UNIT III

Gene transfer in bacteria through transformation, conjugation and transduction; gene mapping by these processes. Transposable elements.

UNIT IV

Gene cloning and gene sequencing. Impact of gene cloning on human welfare. Regulation of gene expression. Recent advances in DNA repair and mutagenesis, Genetic basis of Cancer and cell death.

Practical

Inactivation of microorganisms by different mutagens. Production, isolation and characterization of mutants. Determination of mutation rate. Isolation, characterization and curing of plasmids. Transfer of plasmid by conjugation, electroporation. Tetrad and random spore analysis.

Suggested Readings

- Birge EA. 1981. Bacterial and Bacteriophage Genetics. Springer Verlag.
- Gardner JE, Simmons MJ & Snustad DP.1991.Principles of Genetics.John Wiley & Sons.
- Lewin B.1999. Gene. Vols. VI-IX. John Wiley & Sons.
- Maloy A & Friedfelder D. 1994. Microbial Genetics. Narosa.
- Scaife J, Leach D & Galizzi A 1985. Genetics of Bacteria. Academic Press.
- William Hayes 1981. Genetics of Bacteria. Academic Press.

MICRO 504 : SOIL MICROBIOLOGY 2+1

Objective

Objective of this course is to teach students regarding basics of microbiology related to soil including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

UNIT I

Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Microbial interactions: unculturable soil biota.

UNIT II

Microbiology and biochemistry of root-soil interface; phyllosphere, Biofertilizers, soil enzyme activities and their importance.

UNIT III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Siderophores and antimicrobials. Biochemical composition and biodegradation of soil organic matter and crop residues.

UNIT IV

Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures: Biotic factors in soil development.

Practical

Determination of soil microbial population; Soil microbial biomass; Decomposition studies in soil, Soil enzymes; Measurement of important soil microbial processes such as ammonification, nitrification. N_2 fixation, S oxidation, P solubilization and mineralization of other micro nutrients; Study of rhizosphere effect.

Suggested Readings

- Martin Alexander 1977. Soil Microbiology. John Wiley.
- Paul EA. 2007. Soil Microbiology, Ecology and Biochemistry. 3rd Ed.Academic Press.
- Sylvia et al. 2005. Principles and Applications of Soil Microbiology. 2nd Ed. Pearson Edu.

❖ van Elsas JD, Trevors JT & Wellington EMH. 1997. Modern Soil Microbiology. Marcel Dekker.

MICRO 505 : MICROBIAL BIOTECHNOLOGY 2+1
(Pre-requisite Micro 401, Micro 402, Micro 501)

Objective

To teach students about industrially useful microorganisms and use of fermentor for the production of various primary and secondary metabolites.

Theory

UNIT I

Introduction, scope and historical development; Isolation, screening and genetic improvement of industrially important microorganisms.

UNIT II

Types of fermentation systems; production of various primary and secondary metabolities, e.g. amino acids, organic acids, alcohols, enzymes, organic solvents, antibiotics, etc.

UNIT III

Process scale up steps: laboratory, pilot plant and industrial scales. Down stream processing; Over-production of metabolities; Bioreactor operations, process control.

UNIT IV

Fermented beverages; Production of single cell protein; Steroid transformation; Immobilization of cells/enzymes; Silage production; Waste water treatment.

UNIT V

Use of genetically-engineered microorganisms in biotechnology; Bioinsecticides, biofertilizers, etc. Microbiologically-produced food colours and flavours. Retting of flax.

Practical

Isolation of industrially important microorganisms, their maintenance and improvement. Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery; Study of bio-reactors and their operation: Production of biofertilizers.

Suggested Readings

❖ Cruger W & Cruger A. 2004. Biotechnology - A Textbook of Industrial Microbiology. 2nd Ed. Panima.
❖ Ward OP. 1989. Fermentation Biotechnology. Prentice Hall. Wiseman A. 1983. Principles of Biotechnology. Chapman & Hall.

MICRO 506 : FOOD AND DAIRY MICROBIOLOGY 2+1
(Pre-requisite Micro 401, Micro 403, Micro 501)

Objective

To familiarize the students with recent advances in food microbiology including fermented foods, dairy, food preservation, detection of food- borne diseases, their control measures.

Theory

UNIT I

Introduction and scope; Food Microbiology – A many faceted science; Interrelationship of food microbiology with other sciences; Perspectives on food safety and Food Biotechnology.

UNIT II

Factors of special significance in Food Microbiology – Principles influencing microbial growth in foods; Spores and their significance; Indicator organisms and Microbiological criteria; Microbial spoilage of foods- meat, milk, fruits, vegetables and their products; Food poisoning and food-borne pathogenic bacteria.

UNIT III

Food fermentation; Fermented dairy, vegetable, meat products; Preservatives and preservation methods – physical methods, chemical preservatives and natural antimicrobial compounds. Bacteriocins and their applications; Biologically based preservation systems and probiotic bacteria.

UNIT IV

Advanced techniques in detecting food-borne pathogens and toxins. Hurdle technology and Hazard analysis. Critical control point systems in controlling microbiological hazards in foods.

Practical

Statutory, recommended and supplementary tests for microbiological analysis of various foods: Baby foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers and water.

Suggested Readings

- Bibek Ray.1996. Fundamentals of Food Microbiology. CRC Press.
- Frazier WC & Westhoff DC. 1991. Food Microbiology. 3rd Ed. Tata McGraw Hill.
- George J Banwart. 1989. Basic Food Microbiology. AVI. James M Jay. 1987. Modern Food Microbiology. CBS.
- Peppler HJ & Perlman D.1979. Microbial Technology. 2nd Ed. Academic Press.

MICRO 507 : BACTERIOPHAGES 1+1

Objective

To familiarize students about phages and phage- bacterial interactions.

Theory

UNIT I

Historical developments and classification of bacteriophages.

UNIT II

Physiology, biochemistry, enzymology and molecular biology of phage- bacterial interactions.

UNIT III

Structure, functions and life cycles of different DNA, RNA, lytic and lysogenic phages.

UNIT IV

Phages in the development of molecular biology and genetic engineering.

Practical

Titration of phages and bacteria. Absorption of phages. Preparation of phage stocks. Isolation of new phages and phage resistant bacteria. One step growth curve, phage bursts. Induction of lambda. Complementation of T4 *rII* mutants etc.

Suggested Readings

- Birge EA. 2000. Bacterial and Bacteriophage Genetics. Springer-Verlag.
- Mathew CK. 1972. Bacteriophage Biochemistry. Am. Chemical Soc.
- Mathew CK, Kutter EM, Mosig G & Berget P. 1988. Bacteriophage T4. Plenum Press.
- Nancy T & Trempy J. 2004. Fundamental Bacterial Genetics. Blackwell.
- Stent SG. 1963. Molecular Biology of Bacterial Viruses. WH Freeman.
- Winkler J, Ruger W & Wackernagel W. 1979. Bacterial, Phage and Molecular Genetics - An Experimental Course. Narosa.
- Winkler U & Ruhr W. 1984. Bacteria, Phage and Molecular Genetics. ALA.

MICRO 508 : ENVIRONMENTAL MICROBIOLOGY 2+1

(Pre-requisite Micro 502)

Objective

To teach and create awareness regarding environment, water, soil, air pollution and bioremediation.

Theory

UNIT I

Scope of environmental microbiology. An overview of microbial niches in global environment and microbial activities. Microbiology of air, outdoor and indoor environment in relation to human, animal and plant health and economic activities.

UNIT II

Microbiology of natural waters. Environmental pollution – Deleterious and beneficial role of microorganisms. Environmental microbiology in public health. Microorganism in extreme environments, Environmental determinants that govern extreme environment- Air water interface, extreme of pH, Temperature, Salinity, Hydrostatic pressure.

UNIT III

Microbial technology in pollution abatement, waste management and resource recovery in metal, petroleum and bioenergy fields. Biofuels. Global environmental problems

UNIT IV

Microbial upgradation of fossil fuels and coal gas. Microbial interaction in rumen and gastrointestinal tract. Biodeterioration and Bioremediation. Biodegradation and xenobiotic compounds

Practical

Analysis of natural waters, waste waters and organic waste in relation to water pollution assessment, pollution strength and resource quantification; Quality control tests, waste treatment and anaerobic digestion; Demonstration of waste water treatment processes such as activated sludge processes, biofilter and fluidized bed process.

Suggested Readings

- Campbell R. 1983. Microbial Ecology. Blackwell.
- Hawker LE & Linton AH. 1989. Microorganisms Function, Form and Environment. 2nd Ed. Edward Arnold.
- Mitchell R. 1992. Environmental Microbiology. John Wiley & Sons.
- Richards BN. 1987. Microbes of Terrestrial Ecosystem. Longman.

MICRO 509 : PLANT-MICROBE INTERACTIONS 3+0

(Open for: Microbiology, Biotechnology & Molecular Biology, Genetics, Pl. Physiology, Biochemistry, Plant Breeding & Plant Pathology students; Pre-requisite Micro503/Equiv.,Micro 504)

Objective

To familiarize the students with the biochemical and biophysical mechanisms, genetics, genomics, proteomics and advanced microscopy, spectroscopy of different interfaces of beneficial and pathogenic plant microbe interactions. Molecular analysis of relevant factors in the plant and microbes, and components that modulate plant-microbe interactions for soil and plant health for sustaining crop productivity.

Theory

UNIT I

Different interfaces of interactions - Plant-microbe, microbe-microbe, soil- microbe, soil-plant-microbe interactions leading to symbiotic (rhizobial and mycorrhizal), associative, endophytic and pathogenic interactions. Types of ecosystems: Concept and dynamics of ecosystem, Food chain and energy flow, Microbial communities in the soil. Community dynamics and population interactions employing DGGE, TGGE, T-RFLP.

UNIT II

Quorum-sensing in bacteria, flow of signals in response to different carbon or other substrates and how signals are recognized.

UNIT III

Methodology/resources to study plant-microbe interaction, recombinant inbred lines, biosensors, transcriptome profiling, metabolic profiling, genomics, proteomics and advanced microscopy, spectroscopy of different interfaces.

UNIT IV

Plant and microbial gene expression and signal exchange, global and specific regulators for different interactions. Molecular diversity of microbes, plants and their interactions including transgenic microbes and plants.

Suggested Readings

- Kosuge T & Nester EW. 1989. Plant-Microbe Interactions: Molecular and
- Genetic Perspectives. Vols I-IV. McGraw Hill.
- Verma DPS & Kohn TH. 1984. Genes Involved in Microbe-Plant
- Interactions. Springer Verlag.
- Molecular Plant-Microbe Interactions. Journal Published by APS.

MICRO 510 : INDUSTRIAL MICROBIOLOGY 2+1

(Open for: Microbiology, Biotechnology, Biochemistry, Soil Science, Agronomy, Plant Pathology, Horticulture students; pre- requisite Micro 504, Micro 506)

Objective

To expose the students to the commercial exploitation of microorganisms for production of

useful products. Focus will be on understanding of the techniques involved and the application of microorganisms for agribusiness purpose.

Theory

UNIT I

Biofermentor; Production of wine, beer, lactic acid, acetic acid (vinegar), citric acid, antibiotics, enzymes, vitamins and single cell proteins. Biofuels: Production of ethanol, biogas and hydrogen production.

UNIT II

Brief introduction to bacterial, fungal and insect diseases, Types of chemicals/pesticides used for disease control. Vaccines. Bioagents and Biopesticides Biocontrol agents and their scope in control of plant diseases, nematodes and insect pests. Introduction to phytopathogens, symptoms, pathogenesis molecular aspects of plant pathogens, host-pathogens interactions, host defense mechanisms, disease forecasting and assesment of losses, prevention of epidemics, and disease control. Detailed study of the representative examples of plant diseases casuad by fungi and bacteria

UNIT III

Bioplastics and biopolymers: Microorganisms involved in synthesis of
biodegradable plastics, other pigments, Biosensors: Development of biosensors to detect food contamination and environment pollution, Biodiversity: Structural, biochemical and molecular systematics, Numerical taxonomy. Magnitude and distribution of biodiversity.

UNIT IV

Biofertilizers, Genetic engineering of microbes for enhanced pesticide degradation Mechanisms of pesticide degradation by microbes. Biomining: Coal, mineral and gas formation, prospecting for deposits of crude, oil and gas, recovery of minerals from low-grade ores.

Practical

Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery. Detection of food-borne pathogens, pesticide degradation. Demonstration of biogas production. Production of biocontrol agents.

Suggested Readings

- Alexander M. 1977. Soil Microbiology. John Wiley.
- Hawker LE & Linton AH. 1989. Microorganisms Function, Form and Environment. 2nd Ed. Edward Arnold.
- James M Jaq 1987. Modern Food Microbiology. CBS.
- Paul EA. 2007. Soil Microbiology, Ecology and Biochemistry. 3rd Ed Academic Press.
- Stanbury PF & Whitaker A. 1987. Principles of Fermentation Technology. Pergamon Press.
- Sylvia DM, Fuhrmann JJ, Hartlly PT & Zuberer D. 2005. Principles and Applications of Soil Microbiology. 2nd Ed. Pearson Prentice Hall Edu.

MICRO 511 : BIOFERTILIZER TECHNOLOGY **1+1**

Objective

To familiarize the students and farmers with mass scale production of different agriculturally important microorganisms which are being used as biofertilizers for maintaining the soil and plant health for sustaining crop productivity and their importance in organic farming.

Theory

UNIT I

Different agriculturally important beneficial microorganisms – free living, symbiotic (rhizobial, actinorhizal), associative and endophytic nitrogen fixers including cyanobacteria, taxonomic classification, nodule formation, competitiveness and quantification of N_2 fixed.

UNIT II

Different agriculturally important beneficial microorganisms – phosphate solubilizing bacteria and fungi, including mycorrhiza.

UNIT III

Different agriculturally important beneficial microorganisms – plant growth promoting rhizobacteria.

UNIT IV

Different agriculturally important beneficial microorganisms – Biocontrol microbial inoculants.

UNIT V

Different agriculturally important beneficial microorganisms for recycling of organic waste and compositing, bioremediators and other related microbes.

UNIT VI

Different agriculturally important beneficial microorganisms - selection, establishment, competitiveness, crop productivity, soil & plant health, mass scale production and quality control of bio inoculants. Biofertilizer inoculation and microbial communities in the soil.

Practical

Isolations of symbiotic, asymbiotic, associative nitrogen fixating bacteria. Development and production of efficient microorganisms, Determination of beneficial properties in important bacteria to be used as biofertilizer, Nitrogen fixing activity, indole acetic acid (IAA), siderophore production etc, Bioinoculant production and quality control

Suggested Readings

- Alexander M. 1977. Soil Microbiology. John Wiley.
- Bergerson FJ. 1980. Methods for Evaluating Biological Nitrogen Fixation.John Wiley & Sons.
- Sylvia DM, Fuhrmann JJ, Hartlly PT & Zuberer D. 2005. Principles and Applications of Soil Microbiology. 2nd Ed. Pearson Prentice Hall Edu.
- van Elsas JD, Trevors JT & Wellington EMH. 1997. Modern Soil Microbiology. CRC Press.

MICRO 512 : CYANOBACTERIAL AND ALGAL BIOTECHNOLOGY 2+0

Objective

To teach students about this upcoming fascinating field of microbes develoed at a faster pace, mainly due to photoautotrophic nature of Cyanobacteria, their ability to survive under a variety of habitats and wide diversity of thallus structure and functions. Their importance for mankind is enormous including their role as biofertilizers, nutraceuticals, experimental models, dyes, biofuels and a variety of biochemicals. regarding structure, molecular evolution and properties of cyanobacteria and algae

Theory

UNIT I

Introduction to Cyanobacteria and algae. Definition, occurrence and distribution, thallus structure, reproduction, life cycles, origin and evolution of Cyanobacteria, molecular evolution; role of algae in evolution of land plants and horizontal transfer of genes.

UNIT II

Algal pigments, storage products, carbon metabolism, photosynthesis. Algal culturing and cultivation. Culture types, culture conditions, culture vessels, culture media, sterilization, culture methods, synchronous cultures, photobioreactors, algal density and growth, seaweed cultivation.

UNIT III

Cyanobacterial and algal fuels, Fine chemicals (restriction enzymes etc) and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae - seaweed biotechnology, sustainable aquaculture. Ecology of algae- distribution in soil and water; primary colonizers, carbon sequestration and cycling in soil and water. Cellular differentiation and nitrogen fixation, nitrogen metabolism.

UNIT IV

Algae in pollution - as pollution indicators, eutrophication agents and role inBioremediation. Cyanobacterial and algal toxins, allelopathic interactions, Algae in global warming and environmental sustainability. Cyanobacteria and selected microalgae in agriculture – biofertilizers & algalization; soil conditioners; reclamation of problem soils.

Suggested Readings

- Ahluwalia AS. 2003. Phycology: Principles, Processes and Applications.Daya Publ.
- Barsanti L & Gualtieri P. 2006. Algae: Anatomy, Biochemistry and Biotechnology. Taylor & Francis, CRC Press.

- Carr NG & Whitton BA. 1982. The Biology of Cyanobacteria. Blackwell.
- Herrero A & Flores E. 2008. The Cyanobacteria Molecular Biology, Genomics and Evolution. Calster Academic Press
- Kumar HD. 2005. Introductory Phycology. East West Press.
- Linda E Graham & Lee W Wilcox. 2000. Algae. Prentice Hall.
- Robert A Andersen. 2005. Algal Culturing Techniques. Academic Press.
- Venkataraman LV & Becker EW. 1985. Biotechnology and Utilization of Algae: the Indian Experience. DST.

MICRO 601 : ADVANCES IN FERMENTATION 2+1

Objective

To teach students regarding fermentation industry using industrially useful microorganisms including yeast technology.

Theory

UNIT I

An overview of fermentation - current status of fermentation industry. Fermentor design, high performance bioreactors, mass and energy transfer in bioreactors. Instrumentation and control in fermentors – on line measurements systems, computer application.

UNIT II

Media for microbial fermentation; Criteria in media formulation. An overview of downstream processing.

UNIT III

New strategies for isolation of industrially important microbes and their genetic manipulations; Microbial production of health care products. Antibiotic fermentation research; steroid transformation.

UNIT IV

Recent developments on production of primary and secondary metabolites, Treatment of biological wastes, microbial inoculants and enzymes for waste treatment.

UNIT V

Yeast technology – classification, genetics, strain improvement for brewing, baking and distilleries and topics of current interest in fermentations.

Practical

Industrially important microbes and their genetic manipulations, Fermentation by improved strains of yeast for production of alcohol and beer, Microbial production of important antibiotics, enzymes and organic acids, Bioremediation of industrial effluents

Suggested Readings

- Peppler HJ & Perlman D. 1979. Microbial Technology. 2nd Ed. Academic Press.
- Reed G. 1987. Presscott & Dunn's Industrial Microbiology. 4th Ed. CBS.
- Stanbury PF & Whitaker A. 1987. Principles of Fermentation Technology. Pergamon Press.
- Wiseman A. 1983. Principles of Biotechnology. Chapman & Hall.

MICRO 602 : ADVANCED MICROBIAL PHYSIOLOGY 2+0

(Pre-requisite Micro 502)

Objective

To acquaint students with current topics in molecular microbiology

Theory

UNIT I

Origin, evolution, structure, function and molecular aspects of various cell components.

UNIT II

Differentiation in bacteria, slime molds, yeasts.

UNIT III

Molecular biology of bioluminescence, bacterial virulence. Heat shock response. Extracellular protein secretion in bacteria.

UNIT IV

Topics of current interest in molecular microbiology.

Suggested Readings

❖ Selected articles from journals.

MICRO 603 : REGULATION OF MICROBIAL BIOSYNTHESIS 2+0
(Pre-requisite Micro 502, Micro 503)

Objective

Course imparts thorough knowledge about the synthesis of biomolecules in microorganisms by various pathways and their regulation.

Theory

UNIT I

Regulation of initiation, termination and anti-termination of transcription. Global regulation and differentiation by sigma factor. Regulatory controls in bacteria - inducible and biosynthetic pathways.

UNIT II

Ribosomal RNA and ribosomal proteins regulation under stress condition. Specific regulatory systems; SOS regulatory control; Antisense RNA regulation of gene expression.

UNIT III

Oxidative stress control. Fermentative and respiratory regulatory pathways. Regulation of cell cycle. Lytic and lysogenic cascade.

UNIT IV

Global nitrogen control and regulation of nitrogen fixation and other recent topics of regulatory systems of current interest.

Suggested Readings

❖ Selected articles from journals.

MICRO 604 : CURRENT TOPICS IN SOIL MICROBIOLOGY 2+0
(Pre-requisite Micro 504)

Objective

To make students learn the latest trends in soil microbiology like diversity, biological control and bioremediation.

Theory

UNIT I

Molecular ecology and biodiversity of soil microorganisms; Survival and dispersal of microorganisms.

UNIT II

Microbial successions and transformation of organic matter; Role of microorganisms in soil fertility.

UNIT III

Bioremediation of polluted soils; Biological control.

UNIT IV

Other topics of current interest.

Suggested Readings

❖ Selected articles from journals.

MICRO 605 : Special Problem 0+2

Objective

To allot short research programme to PG students based on current issues of farmers and/or industry oriented problems as per the regional research priorities.

PLANT PHYSIOLOGY

PP 501 : PRINCIPLES OF PLANT PHYSIOLOGY 3+1

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.

UNIT III

Mechanism of water uptake by roots-transport in roots, aquaporins,movement of water in plants – Mycorhizal association on water uptake.

UNIT IV

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 V

Stomata structure and function – mechanism of stomatal movement, antitranspirants.

UNIT VI

Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

UNIT VII

The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants.

UNIT VIII

Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants.

UNIT IX

Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition.

UNIT X

Photorespiration and its relevance. Photosynthesis as a diffusive process and effect of environmental factors on photosynthetic rates. Photosynthesis and translocation of photosynthates 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. Impact of climate change on photosynthesis. Photorespiration and its relevance.

UNIT XI

Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance.

UNIT XII

Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones and their physiological role synthetic growth regulators, growth retardants., Apical dominanace, senescence, fruit growth, development, ripening and abscission.

UNIT XIII

Photo morphogenesis: Photo receptors, phytochrome, cryptochrome, physiology of flowering-Photoperiodism and Vernalisation.

UNIT XIV

Classification of Plant Movements. Physiology of Plant Movements – nastic and tropic movements.

Practical

Measurement of soil water status: Theory and principle of pressure plate apparatus, neutron probe, Measurement of plant water status: Relative water content, water saturation deficits Chardakov's test. Theory and principle of pressure bomb, psychrometer and osmometer, Measurement of transpiration rate. Measurement of vapour pressure deficits, theory and principle of porometry, diffusion prometer and Steady state porometer, Stomatal physiology, influence of ABA on stomatal closing. Mineral nutrients: Demonstration of energy requirement for ion uptake. Deficiencysymptoms of nutrients, Radiant energy measurements, separation and quantification of chlorophylls, O2 evolution during photosynthesis, Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration, Respiration rates, Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene. Demonstration of photoperiodic response of plants in terms of flowering.

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 502 : PLANT DEVELOPMENTAL BIOLOGY - PHYSIOLOGICAL AND MOLECULAR BASIS 2 +0

Objective

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

Theory

UNIT I

Plant Biodiversity, Concept of evolution in plants.

UNIT II

General Aspects – Novel features of plant growth and development; Concept of plasticity in plant development; Analysing plant growth.

UNIT III

Seed Germination and Seedling Growth – Mobilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth.

UNIT IV

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

UNIT V

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

UNIT VI

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

UNIT VII

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

UNIT VIII

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

UNIT IX

Embryonic Pattern Formation – Maternal gene effects; Zygotic gene effects; Homeotic 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 503 : PHYSIOLOGICAL AND MOLECULAR RESPONSES 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 resurrection 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 membrane 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.

UNIT X

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

Practical

Measurement of water status of plants, determination of osmotic potential by vapour pressure and freezing point depression, Determination of soil water potential and content by psychrometry and other systems. Stress imposition and quantification, Stress –stomatal

conductance. Canopy temperature as a reflection of transpiration and root activity,Water use – efficiency, Determination at whole plant and single leaf level,Root- shoot signals-ABA and cytokinin effect on stomatal behavior, Heat tolerance and membrane integrity. Sullivans heat tolerance test, chilling tolerance- Galactolipase and free fatty acid levels as biochemical markers for chilling damage, Cold induced inactivation of O2 evolution of chloroplasts- as a screening technique 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 504 : 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 classifiacation of palnt growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. tricontanol, Phenols – polyamines, jasmonates, concept of death hormone.

UNIT II

Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- Auxins, Gibberlins, cytokinins, Abscisic acid and Ethylene Brassinosteroids.

UNIT III

Hormone mutants and transgenic plants in understanding role of hormones.

UNIT IV

Signal perception.transduction, and effect at functional gene level of different hormones- Auxins- cell elongation, Gibberellins -, germination of dormant seeds, cytokinins- cell division. Retardation of senescence of plant parts, Abscisic acid-Stomatal closure and induction of drought resistance, Ethylene- fruit ripening.

UNIT V

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

Synthetic growth regulators- Classification, their effect on plant growth and development. Practical utility in agriculture and horticulture.

Practical

Quantification of Hormones- Principles of bioassays, physico chemical techniques and immunoassay, Extraction of hormones from plant tissue. Auxins- bioassays- auxins effect 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 L & 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 PlantGrowth Analysis. Edward Arnold.
- John H, Thornley M & Johnson IR. Plant and Crop Modeling: AMathematical 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; Repair and recombination.

Practical

Culturing and transformation of bacteria; genomic DNA and plasmid DNA isolation from bacteria, restriction enzyme digestion and analysis by agarose gel electrophoresis, isolation of genomic DNA and RNA from plants and quantification; Culture of 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 CULTUREAND TRANSFORMATION 2+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 **somatic** embryogenesis, **synthetic seeds.** And organogenesis and their practical applications. **Methods of micropropagation and** 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 2+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. CO_2 Concentration 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

Physiological screening methods of 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.

PP 512 : PLANT CELL METABOLISM 2+1

Objective

To apprise the students regarding various metabolic events at cellular level and its impact on crop physiology.

UNIT I

Compartmentation of cellular metabolism in the cell and role of various cell organelles-plastids, mitochondria, ribosomes, endoplasmic reticulum, nucleus etc. in cell metabolism.

UNIT II

Carbohydrate metabolism :Synthesis of sucrose, oligo, starch and polysaccharides.

UNIT III

Nitrogen metabolism: Inorganic nitrogen species (N2, NO3 and NH3) and their reduction to aminoacids, protein synthesis and nucleic acids.

UNIT IV

Lipid metabolism- Storage, protective and structural lipids. Biosynthesis of fattyacids, diacyl and triacyl glycerol, fatty acids of storage lipids. Secondary metabolites and their significance in plant defence mechanism.

Practical

Estimation of reducing sugars and starch. Estimation of NO3, free aminoacids in the xylem exudates, quantification of soluble proteins and sugars. Estimation of key enzymes of different metabolic pathways under study.

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.
- Atkinson, D. E. (1977). Cellular energy metabolism and its regulation. Academic Press, New York.
- Street, H.E. and Cockburn (year). Plant Cell Metabolism.

PP 513 : Physiological responses of plants to Biotic Stresses 1+1

Objective

To apprise the students regarding biotic stress to plant and its physiological basis.

UNIT I

Response of plants to biotic stresses and their effect on plant productivity. Interaction between biotic and abiotic stresses.

UNIT II

Plant-pathogen interaction and disease development; molecular mechanisms of fungal and bacterial infection an plants; changes in metabolism, cell wall composition and vascular transport on diseased plants.

UNIT III

Plant defense response, morphological, structural, biochemical and physiological resistance mechanisms, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance, phytoalexins, altered respiration in defense mechanisms.

UNIT IV

Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viriods, pathogen-derived resistance.

UNIT V

Mechanism of resistance against insect-pests.

Practicals:

Morphological and Physiological symptoms related to bacterial, fungal and viral diseases.Total phenol from diseased and healthy plants. Polyphenol oxidase assay and isozymes plant species differing in tolerance. Peroxidase assay and isozymes plant species differing in tolerance. Chitinase assay from tolerant and susceptible plant genotypes.Assay and SDS PAGE of native and PR proteins.

Suggested Readings:

- Levitt, J. 1980. Responses of Plants to Environmental Stresses, Academic Press, New York.
- Fritig, B. and Legrand, M. 1993. Mechanism of Plant Defence Responses, Dardecht Kluwer Academic Press.
- Primrose, S.B. 1989. Introduction to Modern Virology, Blackwell Scientific Publications, London. Paris. Berlin
- Crute, I.R., Bruden, J.J. and Holub, E.B. (Eds.). 1997, Gene-for-Gene Relationship in Host-Parasite Interactions, Wallingford, U.K.: CAB Int.
- Chessin. M., DeBorde. D. ad Zipf, A. 1995. Antiviral Protiens in Higher Plants, CRC Press, Boca Raton.
- Dengl, J. 1995. Bacterial Pathogenesis of Plants and Animals : Molecular and Cellular Mechanisms, Springer Verlag, Heidelberg, Germany.

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 1+2

Objective

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

Theory

UNIT I

Recent experimental techniques to study various physiological processes, Photosynthetic gas exchange measurements, light and CO2 response curves-determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements. Measurement of respiration and photorespiration.

UNIT II

Estimation of water use efficiency at whole plant and single leaf level. Use of stable isotopes to understand physiological processes.

UNIT III

Radio isotopes in plant biology.

UNIT IV

Tools and techniques (molecular and biochemical) to study physiological processes and to screen & assess stress responses in plants, such as (a) DNA & RNA isolation, cDNA synthesis & library construction, semiquantitative & quantitative RT-PCR, northern blot, immunoassays; (b) techniques for defined physiological processes.

UNIT V

Methods to phenotype germplasm for specific physiological traits.

UNIT VI

Quantification of mineral nutrients using advanced instruments like AAS, & ICP.

UNIT VII

Techniques in plant transformation & analysis of transgenic plants

UNIT VIII

Molecular markers- genetic distance and mapping population concept of linkage maps and identification of QTLS.

UNIT IX

Instrumentation: Acquaintance of the operation of specific instruments important in physiological research like Mass spec., phosphor-imager, DNA sequencer, spectro-fluorometer, oxygen electrode, etc.

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

Introduction to carbon sequestration. 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.

UNIT X

Concepts of physiological maturity of seeds, post harvest changes in biochemical constituents in field crops, loss of nutritive value, environmental factors influencing post harvest deterioration of seeds and fruits.

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

PLANT MOLECULAR BIOLOGY AND BIOTECHNOLOGY

MBB 501 : PRINCIPLES OF BIOTECHNOLOGY 2+1

Objective

To familiarize the students with the fundamental principles of Biotechnology, various developments in Biotechnology and its potential applications.

Theory

UNIT I

History, scope and importance; DNA structure, function and metabolism.

UNIT II

DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; Gene libraries; PCR amplification; Plant and animal cell and tissue culture techniques and their applications.

UNIT III

Molecular markers and their applications; DNA sequencing; Applications of gene cloning in basic and applied research; Genetic engineering and transgenics; Genomics, transcriptomics and proteomics.

UNIT IV

General application of biotechnology in Agriculture, Medicine, Animal husbandry, Environmental remediation, Energy production and Forensics; Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Practical

- Isolation of genomic and plasmid DNA
- Gel electrophoresis techniques
- Restriction enzyme digestion, ligation, transformation and screening of transformants

- PCR and molecular marker analysis
- Plant tissue culture: media preparation, cell and explant culture, regeneration and transformation.

Suggested Readings

- Becker JM, Coldwell GA & Zachgo EA. 2007. Biotechnology - a Laboratory Course. Academic Press.
- Brown CM, Campbell I & Priest FG. 2005. Introduction to Biotechnology. Panima Pub.
- Brown TA. Gene Cloning and DNA Analysis. 5th Ed. Blackwell Publishing.
- Dale JW & von Schantz M. 2002. From Genes to Genomes: Concepts and Applications of DNA Technology. John Wiley & Sons.
- Gupta PK. 2004. Biotechnology and Genomics. Rastogi Publications. Sambrook J, Fritsch T & Maniatis T. 2001. Molecular Cloning - a Laboratory Manual. 2nd Ed. Cold Spring Harbour Laboratory Press.
- Singh BD. 2007. Biotechnology Expanding Horiozon. Kalyani Publishers.

MBB 502 : FUNDAMENTALS OF MOLECULAR BIOLOGY 3+0

Objective

To familiarize the students with the basic cellular processes at molecular level.

Theory

UNIT I

Historical developments of molecular biology; Nucleic acids as genetic material; Chemistry, structure and properties of DNA and RNA.

UNIT II

Genome organization in prokaryotes and eukaryotes; Chromatin structure and function; DNA replication; DNA polymerases, topoisomerases, DNA ligase, etc; Molecular basis of mutations; DNA repair mechanisms.

UNIT III

Transcription process; RNA processing; Reverse transcriptase; RNA editing; Ribosomes structure and function; Organization of ribosomal proteins and RNA genes; Genetic code; Aminoacyl tRNA synthases.

UNIT IV

Translation and post-translational modifications; Operon concept; Attenuation of *trp* operon; important features of gene regulation in eukaryotes.

Suggested Readings

- Lewin B. 2008. Gene IX. Peterson Publications/ Panima.
- Malacinski GM & Freifelder D. 1998. Essentials of Molecular Biology. 3rd Ed. Jones & Bartlett Publishers.
- Nelson DL & Cox MM. 2007. Lehninger's Principles of Biochemistry. W.H. Freeman& Co.
- Primrose SB. 2001. Molecular Biotechnology. Panima.
- Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. Molecular Biology of the Gene. 6th Ed. Pearson Education International.

MBB 503 : MOLECULAR CELL BIOLOGY 3+0

Objective

To familiarize the students with the cell biology at molecular level.

Theory

UNIT I

General structure and constituents of cell; Similarities and distinction between plant and animal cells; Cell wall, cell membrane, structure and composition of biomembranes, cell surface related functions.

UNIT II

Structure and function of major organelles: Nucleus, Chloroplasts, Mitochondria, Ribosomes, Lysosomes, Peroxisomes, Endoplasmic reticulum, Microbodies, Golgi apparatus, Vacuoles, etc.

UNIT III

Organellar genomes and their manipulation; Ribosomes in relation to cell growth and division; Cyto-skeletal elements.

UNIT IV

Cell division and regulation of cell cycle; Membrane transport; Transport of water, ion and biomolecules; Signal transduction mechanisms; Protein targeting.

Suggested Readings

- Gupta PK. 2003. Cell and Molecular Biology. 2nd Ed. Rastogi Publ.
- Lodish H. 2003. Molecular Cell Biology. 5th Ed. W.H. Freeman & Co.
- Primrose SB. 2001. Molecular Biotechnology. Panima.

MBB 504 : PLANT TISSUE CULTURE AND GENETIC TRANSFORMATION 1+2

Objective

To familiarize the students and provide hands on training on various techniques of plant tissue culture, genetic engineering and transformation.

Theory

UNIT I

History of plant cell and tissue culture; Culture media; Various types of culture; callus, suspension, nurse, root, meristem, etc.; *In vitro* differentiation: organogenesis and somatic embryogenesis; Plant growth regulators: mode of action, effects on *in vitro* culture and regeneration; Molecular basis of plant organ differentiation.

UNIT II

Micropropagation; Anther and microspore culture; Somaclonal variation; *In vitro* mutagenesis; *In vitro* fertilization; *In vitro* germplasm conservation; Production of secondary metabolites; Synthetic seeds.

UNIT III

Embryo rescue and wide hybridization; Protoplast culture and regeneration; Somatic hybridization: protoplast fusion, cybrids, asymmetric hybrids, etc.

UNIT IV

Methods of plant transformation; Vectors for plant transformation; Genetic and molecular analyses of transgenics; Target traits and transgenic crops; Biosafety issues, testing of transgenics, regulatory procedures for commercial approval.

Practical

- Laboratory set-up.
- Preparation of nutrient media; handling and sterilization of plant material; inoculation, subculturing and plant regeneration.
- Anther and pollen culture.
- Embryo rescue.
- Suspension cultures and production of secondary metabolites.
- Protoplast isolation, culture and fusion.
- Gene cloning and vector construction
- Gene transfer using different methods, reporter gene expression, selection of transformed tissues/plants, molecular analysis.

Suggested Readings

- Bhojwani SS. 1983. Plant Tissue Culture: Theory and Practice. Elsevier.
- Christou P & Klee H. 2004. Handbook of Plant Biotechnology. John Wiley & Sons.
- Dixon RA. 2003. Plant Cell Culture. IRL Press.
- George EF, Hall MA & De Klerk GJ. 2008. Plant Propagation by Tissue Culture. Agritech Publ.
- Gupta PK. 2004. Biotechnology and Genomics. Rastogi Publ.
- Herman EB. 2005-08. Media and Techniques for Growth, Regeneration and Storage. Agritech Publ.
- Pena L. 2004. Transgenic Plants: Methods and Protocols. Humana Press.
- Pierik RLM. 1997. In vitro Culture of Higher Plants. Kluwer.
- Singh BD. 2007. Biotechnology: Expanding Horiozon. Kalyani.

MBB 505 : TECHNIQUES IN MOLECULAR BIOLOGY-I 0+3

Objective

To provide hands on training on basic molecular biology techniques.

Practical

UNIT I

Good lab practices; Biochemical techniques: Preparation of buffers and reagents, Principle of centrifugation, Chromatographic techniques (TLC, Gel Filtration Chromatography, Ion exchange Chromatography, Affinity Chromatography).

UNIT II

Gel electrophoresis- agarose and PAGE (nucleic acids and proteins); Growth of bacterial culture and preparation of growth curve; Isolation of plasmid DNA from bacteria; Growth of lambda phage and isolation of phage DNA; Restriction digestion of plasmid and phage DNA; Isolation of high molecular weight DNA and analysis.

UNIT III

Gene cloning – Recombinant DNA construction, transformation and selection of transformants; PCR and optimization of factors affecting PCR.

UNIT IV

Dot blot analysis; Southern hybridization; Northern hybridization; Western blotting and ELISA; Radiation safety and non-radio isotopic procedure.

Suggested Readings

- Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. Short Protocols in Molecular Biology. John Wiley.
- Kun LY. 2006. Microbial Biotechnology. World Scientific.
- Sambrook J, Russel DW & Maniatis T. 2001. Molecular Cloning: a Laboratory Manual. Cold Spring Harbour Laboratory Press.

MBB 506 : MICROBIAL/ INDUSTRIAL BIOTECHNOLOGY 2+1

Objective

To familiarize about the various microbial processes/systems/activities, which have been used for the development of industrially important products/processes.

Theory

UNIT I

Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms.

UNIT II

Primary metabolism products, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non ribosomal peptide antibiotics; Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry.

UNIT III

Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio-transformations, Bio- augmentation with production of vitamin C as a case study; Bioreactors, their design and types; Immobilized enzymes based bioreactors; Microencapsulation technologies for immobilization of microbial enzymes.

UNIT IV

Industrial biotechnology for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bio- remediation of soil; Production of eco-friendly agricultural chemicals, bio- pesticides, bio-herbicides, bio-fertilizers, bio-fuels, etc.

Practical

- Isolation of industrially important microorganisms, their maintenance and improvement.
- Production of industrial compounds such as alcohol, beer, citric acid,
- lactic acid and their recovery.
- Study of bio-reactors and their operations. iv. Production of biofertilizers.
- Experiments on microbial fermentation process, harvesting purification and recovery of

end products.
- Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomass estimation.
- Determination mass transfer co-efficients.

Suggested Readings

❖ Huffnagle GB & Wernick S. 2007. The Probiotics Revolution: The Definitive Guide to Safe, Natural Health. Bantam Books.
❖ Kun LY. 2006. Microbial Biotechnology. World Scientific.
❖ Primrose SB. 2001. Molecular Biotechnology. Panima.

MBB 507 : MOLECULAR BREEDING 2+0

Objective

To familiarize the students about the use of molecular biology tools in plant breeding.

Theory

UNIT I

Principles of plant breeding; Breeding methods for self and cross pollinated crops; Heterosis breeding; Limitations of conventional breeding; Aspects of molecular breeding.

UNIT II

Development of sequence based molecular markers -SSRs and SNPs; Advanced methods of genotyping; Mapping genes for qualitative and quantitative traits.

UNIT III

QTL mapping using structured populations; AB-QTL analysis; Association mapping of QTL; Fine mapping of genes/QTL; Map based gene/QTL isolation and development of gene based markers; Allele mining by TILLING and Eco-TILLING; Use of markers in plant breeding.

UNIT IV

Marker assisted selection (MAS) in backcross and heterosis breeding; Transgenic breeding; Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples.

Suggested Readings

❖ Chittaranjan K. 2006-07. Genome Mapping and Molecular Breeding in Plants. Vols. I-VII. Springer.
❖ Newbury HJ. 2003. Plant Molecular Breeding. Blackwell Publ.
❖ Weising K, Nybom H, Wolff K & Kahl G. 2005. DNA Fingerprinting in Plants: Principles, Methods and Applications. Taylor & Francis.

MBB 508 : GENOMICS AND PROTEOMICS 2+0

Objective

To familiarize the students with recent tools used for genome analysis and their applications.

Theory

UNIT I

Structural genomics: Classical ways of genome analysis, large fragment genomic libraries; Physical mapping of genomes; Genome sequencing, sequence assembly and annotation; Comparative genomics, etc.

UNIT II

Functional genomics: DNA chips and their use in transcriptome analysis; Mutants and RNAi in functional genomics; Metabolomics and ionomics for elucidating metabolic pathways, etc.

UNIT III

Proteomics - Protein structure, function and purification; Introduction to basic proteomics technology; Bio-informatics in proteomics; Proteome analysis, etc.

UNIT IV

Applications of genomics and proteomics in agriculture, human health and industry.

Suggested Readings

❖ Azuaje F & Dopazo J. 2005. Data Analysis and Visualization in Genomics and Proteomics. John Wiley & Sons.
❖ Brown TA. 2007. Genome III. Garland Science Publ.

- Campbell AM & Heyer L. 2004. Discovery Genomics, Proteomics and Bioinformatics. Pearson Education.
- Gibson G & Muse SV. 2004. A Primer of Genome Science. Sinauer Associates.
- Jollès P & Jörnvall H. 2000. Proteomics in Functional Genomics: Protein Structure Analysis. Birkhäuser.
- Kamp RM. 2004. Methods in Proteome and Protein Analysis. Springer.
- Primrose SB & Twyman RM. 2007. Principles of Genome Analysis and Genomics. Blackwell.
- Sensen CW. 2005. Handbook of Genome Research. Vols. I, II. Wiley CVH.

MBB 509 : TECHNIQUES IN MOLECULAR BIOLOGY-II 0+3

Objective

To provide hands on training on various molecular techniques used in molecular breeding and genomics.

Practical

UNIT I

Construction of gene libraries; Synthesis and cloning of cDNA and RT- PCR analysis; Real time PCR and interpretation of data.

UNIT II

Molecular markers (RAPD, SSR, AFLP etc) and their analysis; Case study of SSR markers (linkage map, QTL analysis etc); SNP identification and analysis; Microarray studies and use of relevant software.

UNIT III

Proteomics (2D gels, mass spectrometry, etc.); RNAi (right from designing of construct to the phenotyping of the plant); Yeast 1 and 2-hybrid interaction.

UNIT IV

Generation and screening of mutants; Transposon mediated mutagenesis.

Suggested Readings

- Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. Short Protocols in Molecular Biology. Wiley.
- Caldwell G, Williams SN & Caldwell K. 2006. Integrated Genomics: A Discovery-Based Laboratory Course. John Wiley.
- Sambrook J, Russel DW & Maniatis T. 2001. Molecular Cloning: a Laboratory Manual. Cold Spring Harbour Laboratory Press.

MBB 510 : BIOSAFETY, IPR AND BIOETHICS 2+0

Objective

To discuss about various aspects of biosafety regulations, IPR and bioethic concerns arising from the commercialization of biotech products.

Theory

UNIT I

Biosafety and risk assessment issues; Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety, Cross border movement of germplasm; Risk management issues - containment.

UNIT II

General principles for the laboratory and environmental biosafety; Health aspects; toxicology, allergenicity, antibiotic resistance, etc; Impact on environment: gene flow in natural and artificial ecologies; Sources of gene escape, tolerance of target organisms, creation of superweeds/superviruses, etc.

UNIT III

Ecological aspects of GMOs and impact on biodiversity; Monitoring strategies and methods for detecting transgenics; Radiation safety and non- radio isotopic procedure; Benefits of transgenics to human health, society and the environment.

UNIT IV

The WTO and other international agreements; Intellectual properties, copyrights, trademarks, trade secrets, patents, geographical indications, etc; Protection of plant variety and farmers right act; Indian patent act and amendments, patent filing; Convention on biological diversity; Implications of intellectual property rights on the commercialization of biotechnology products.

Suggested Readings

- Singh BD. 2007. Biotechnology: Expanding Horizon. Kalyani. http://patentoffice.nic.in
- www.wipo.org www.dbtindia.nic.in www.dbtbiosafety.nic.in

MBB 511 : ANIMAL BIOTECHNOLOGY 3+0

Objective

Intended to provide an overview and current developments in different areas of animal biotechnology.

Theory

UNIT I

Structure of animal cell; History of animal cell culture; Cell culture media and reagents, culture of mammalian cells, tissues and organs, primary culture, secondary culture, continuous cell lines, suspension cultures, somatic cell cloning and hybridization, transfection and transformation of cells, commercial scale production of animal cells, application of animal cell culture for *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

UNIT II

Introduction to immune system, cellular and hormonal immune response, history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, hybridoma technology, phage display technology for production of antibodies, antigen-antibody based diagnostic assays including radioimmunoassays and enzyme immunoassays, immunoblotting, nucleic acid based diagnostic methods, commercial scale production of diagnostic antigens and antisera, animal disease diagnostic kits, probiotics.

UNIT III

Structure of sperms and ovum, cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, *in vitro* fertilization, culture of embryos, cryopreservation of embryos, embryo transfer, embryo-spliting, embryo sexing, transgenic manipulation of animal embryos, different applications of transgenic animal technology, animal viral vectors, animal cloning basic concept, cloning from- embryonic cells and adult cells, cloning of different animals, cloning for conservation for conservation endangered species, ethical, social and moral issues related to cloning, *in situ* and *ex situ* preservation of germplasm, *in utero* testing of foetus for genetic defects, pregnancy diagnostic kits, anti-fertility animal vaccines, gene knock out technology and animal models for human genetic disorders.

UNIT IV

Introduction to different breeds of cattle, buffalo, sheep, goats, pigs, camels, horses, canines and poultry, genetic characterization of livestock breeds, marker assisted breeding of livestock, introduction to animal genomics, different methods for characterization of animal genomes, SNP, STR, QTL, RFLP, RAPD, genetic basis for disease resistance, Transgenic animal production and application in expression of therapeutic proteins. Immunological and nucleic acid based methods for identification of animal species, detection of meat adulteration using DNA based methods, detection food/feed adulteration with animal protein, identification of wild animal species using DNA based methods using different parts including bones, hair, blood, skin and other parts confiscated by anti-poaching agencies.

Suggested Readings

- Gordon I. 2005. Reproductive Techniques in Farm Animals. CABI.
- Kindt TJ, Goldsby RA & Osbrne BA. 2007. Kuby Immunology. WH Freeman.
- Kun LY. 2006. Microbial Biotechnology. World Scientific.
- Levine MM, Kaper JB, Rappuoli R, Liu MA, Good MF. 2004. New Generation Vaccines. 3rd Ed. Informa Healthcare.

- Lincoln PJ & Thomson J. 1998. Forensic DNA Profiling Protocols. Humana Press.
- Portner R. 2007. Animal Cell Biotechnology. Humana Press.
- Spinger TA. 1985. Hybridoma Technology in Biosciences and Medicine. Plenum Press.
- Twyman RM. 2003. Advanced Molecular Biology. Bios Scientific.

MBB 512 : IMMUNOLOGY AND MOLECULAR DIAGNOSTICS 2+1

Objective

To discuss the application of various immunological and molecular diagnostic tools.

Theory

UNIT I

History and scope of immunology; Components of immune system: organs, tissues and cells, Immunoglobulin chemistry, structure and functions; Molecular organization of immunoglobulins and classes of antibodies.

UNIT II

Antibody diversity; antigens, haptens, antigens- antibody interactions; immuno-regulation and tolerance; Allergies and hypersensitive response; Immunodeficiency; Vaccines; Immunological techniques.

UNIT III

Immunological application in plant science, monoclonal antibodies and their uses, molecular diagnostics. Introduction to the basic principles of molecular technology and techniques used in pathogen detection, Principles of ELISA and its applications in viral detection.

UNIT IV

Basics and procedures of PCR, Real time PCR, PCR based and hybridization based methods of detection, microarrays based detection, multiplexing etc, detection of soil borne and seed born infections, transgene detection in seed, planting material and processed food, molecular detection of varietal impurities and seed admixtures in commercial consignments.

Practical

- Preparation of buffers and reagents.
- Immunoblotting, immunoelectrophoresis and fluorescent antibody test. iii. Enzyme immunoassays including ELISA western blotting.
- Extraction and identification of DNA/RNA of pathogenic organisms.
- Restriction hybridoma technique and production of monoclonal antibodies.
- Immunogenic proteins, expression and immunogenecity studies, purification of immunogenic protein and immunization of laboratory animals.

Suggested Readings

- Bloom BR & Lambert P-H. 2002. The Vaccine Book. Academic Press.
- Elles R & Mountford R. 2004. Molecular Diagnosis of Genetic Disease. Humana Press.
- Kindt TJ, Goldsby RA & Osbrne BA. 2007. Kuby's Immunology. WH Freeman.
- Levine MM, Kaper JB, Rappuoli R, Liu MA & Good MF. 2004. New Generation Vaccines. 3rd Ed. Informa Healthcare.
- Lowrie DB & Whalen R. 2000. DNA Vaccines. Humana Press.
- Male D, Brostoff J, Roth DB & Roitt I. 2006. Immunology. Elsevier.
- Rao JR, Fleming CC & Moore JE. 2006. Molecular Diagnostics. Horizon Bioscience.
- Robinson A & Cranage MP. 2003. Vaccine Protocols. 2nd Ed. Humana Press.
- Spinger TA, 1985. Hybridoma Technology in Biosciences and Medicine. Plenum Press.

MBB 513 : NANO-BIOTECHNOLOGY 3+0

Objective

Understanding the molecular techniques involved in structure and functions of nano-biomolecules in cells such as DNA, RNA and proteins.

Theory

UNIT I

Introduction to Biomacromolecules: The modern concepts to describe the conformation and dynamics of biological macromolecules: scattering techniques, micromanipulation techniques, drug delivery applications etc.

UNIT II

Cellular engineering: signal transduction in biological systems, feedback control signaling pathways, cell-cell interactions etc. Effects of physical, chemical and electrical stimuli on cell function and gene regulation.

UNIT III

Chemical, physical and biological properties of biomaterials and bioresponse: biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems,

UNIT IV

Preparation and characterization of nanoparticles; Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chiptechnologies, Nano-imaging, Metabolic engineering and Gene therapy.

Suggested Readings

- Nalwa HS. 2005. Handbook of Nanostructured Biomaterials and Their
- Applications in Nanobiotechnology. American Scientific Publ. Niemeyer CM & Mirkin CA. 2005. Nanobiotechnology. Wiley
- Interscience.

MBB 551 : PRINCIPLES OF GENETICS 2+1

Objective

This course is aimed at understanding the basic concepts of genetics, helping students to develop their analytical, quantitative and problem- solving skills from classical to molecular genetics.

Theory

UNIT I

Early concepts of inheritance; Discussion on Mendel's paper; Sex determination, differentiation and sex-linkage, Sex-influenced and sex- limited traits; Linkage, recombination and genetic mapping in eukaryotes, Somatic cell genetics.

UNIT II

Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes; Mutations and mutagenic agents.

UNIT III

Genetic code and protein biosynthesis; Gene regulation, Genes in development; Extra chromosomal inheritance, Male sterility and incompatibility; Recombination in bacteria, fungi and viruses, tetrad analysis.

UNIT IV

Inheritance of quantitative traits; Concepts in population genetics; Genes and behavior; Genetics and evolution; Recombinant DNA technology; Genetic fine structure analysis, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families; An overview of some recent discoveries in the field of genetics.

Practical

- Laboratory exercises in probability and chi-square.
- Demonstration of genetic principles using laboratory organisms. iii. Chromosome mapping using three point test cross.
- Tetrad analysis.
- Induction and detection of mutations through genetic tests. vi. Pedigree analysis in humans.
- Numerical problems on Hardy Weinberg Equilibrium, Quantitative
- inheritance and Molecular genetics.

Suggested Readings

- Klug WS & Cummings MR. 2003 Concepts of Genetics. Peterson Education.
- Lewin B. 2008. Genes IX. Jones & Bartlett Publ.
- Russell PJ. 1998. Genetics. The Benzamin/Cummings Publ. Co.
- Strickberger MW.1990. Genetics. Collier MacMillan.

❖ Tamarin RH. 1999. Principles of Genetics. Wm. C. Brown Publs.
❖ Uppal S, Yadav R, Subhadra & Saharan RP. 2005. Practical Manual on Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar.

MBB 552 : BASIC BIOCHEMISTRY 2+1

Objective

To provide elementary knowledge/overview of structure, functions and metabolism of biomolecules.

Theory

UNIT I

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers.

UNIT II

Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids.

UNIT III

Structure and biological functions of vitamins, enzymes classification and mechanism of action; regulation, factors affecting enzyme action. Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

UNIT IV

Metabolism of carbohydrates, photosynthesis and respiration, oxidative phosphorylation, lipids, proteins and nucleic acids. DNA replication, transcription and translation; recombinant DNA technology, Nutritional aspects of carbohydrates, lipids, proteins and minerals.

Practical

- Preparation of standard and buffer solutions.
- Extraction and estimation of sugars and amino acids. iii. Estimation of proteins by Lowry's method.
- Estimation of DNA and RNA by Diphenyamine and orcinol methods. v. Estimation of ascorbic acid.
- Separation of biomolecules by TLC and paper chromatography

Suggested Readings

❖ Conn EE & Stumpf PK. 1987. Outlines of Biochemistry. John Wiley. Metzler DE. Biochemistry. Vols. I, II. Wiley International.
❖ Nelson DL & Cox MM. 2004. Lehninger's Principles of Biochemistry. MacMillan.
❖ Voet D & Voet JG. Biochemistry. 3rd Ed. Wiley International.

MBB 553 : BIOSTATISTICS AND COMPUTERS 2+1

Objective

This is the special course for M.Sc. students of Biotechnology. They are exposed to various statistical methods to analyze their experimental data.

Theory

UNIT I

Aims, scope and idea of elementary statistics; Measures of central tendency and dispersion, skewness and kurtosis.

UNIT II

Concept of probability and probability laws, mathematical expectation, moments, moments generating function; Standard probability distributions- Binomial, Poisson and Normal distributions.

UNIT III

Tests of significance based on Z, χ^2, t and F statistics; Correlation and regression, curve fitting by least squares methods.

UNIT IV

Basic principles, organization and operational aspects of computers, operating systems. Introduction to MS-Office, MS-Word, MS-Excel. Statistical Data analysis based on above topics through MS-Excel.

Practical

- Data analysis using probability, test of significance ii. Correlation and regression analysis
- Usage of MS-Windows
- Exercises on test processing, spreadsheet and DBMS
- SPSS

Suggested Readings

- ❖ Agarwal BL. 2003. Basic Statistics. New Age.
- ❖ Gupta SP. 2004. Statistical Methods. S. Chand & Sons.
- ❖ Dutta NK. 2002. Fundamentals of Bio-Statistics. Kanishka Publ.

MBB 554 : PRINCIPLES OF MICROBIOLOGY 2+1

Objective

To acquaint the students with history, classification and role of microbiology in agriculture, food and environment.

Theory

UNIT I

Development of Microbiology in the 18^{th} and 19^{th} century. Morphology, structure and function of prokaryotic and eukaryotic cell. Archea.
Classification of prokaryotes – Basic principles and techniques used in bacterial classification.

UNIT II

Evolutionary relationship among prokaryotes. Phylogenetic and numerical taxonomy. Use of DNA and r-RNA sequencing in classifications.

UNIT III

Study of major groups of bacteria belonging to Gracilicutes, Firmicutes, Tanericutes and Mendosicutes.

UNIT IV

Viruses – morphology, classification and replication of plant, animal and bacterial viruses. Cultivation methods of viruses. Immune response – specific and non-specific resistance. Normal microflora of human body; some common bacterial and viral diseases of humans and animals.

Practical

- Methods of isolation, purification and maintenance of microorganisms from different environments (air, water, soil, milk and food).
- Enrichment culture technique – isolation of asymbiotic, symbiotic nitrogen fixing bacteria. Isolation of photosynthetic bacteria.
- Use of selective media, antibiotic resistance and isolation of antibiotic producing microorganisms.
- Morphological, physiological and biochemical characterization of bacteria.

Suggested Readings

- ❖ Brock TD. 1961. Milestones in Microbiology. Infinity Books.
- ❖ Pelczar ML Jr. 1997. Microbiology. Tata McGraw Hill.
- ❖ Stainier RY, Ingraham JL, Wheelis ML & Painter PR. 2003. General Microbiology. MacMillan.
- ❖ Tauro P, Kapoor KK & Yadav KS. 1996. Introduction to Microbiology. Wiley Eastern.

MBB 555 : INTRODUCTION TO BIOINFORMATICS 2+1

Objective

To impart an introductory knowledge about the subject of bioinformatics to the students studying any discipline of science.

Theory

UNIT I

Introduction, biological databases – primary, secondary and structural, Protein and Gene Information Resources – PIR, SWISSPROT, PDB, genebank, DDBJ. Specialized genomic resources.

UNIT II

DNA sequence analysis, cDNA libraries and EST, EST analysis, pairwise alignment techniques, database searching, multiple sequence alignment.

UNIT III

Secondary database searching, building search protocol, computer aided drug design – basic principles, docking, QSAR.

UNIT IV

Analysis packages – commercial databases and packages, GPL software for Bioinformatics, web-based analysis tools.

Practical

- Usage of NCBI resources
- Retrival of sequence/structure from databases iii. Visualization of structures
- Docking of ligand receptors v. BLAST exercises.

Suggested Readings

- ❖ Attwood TK & Parry-Smith DJ. 2003. Introduction to Bioinformatics. Pearson Education.
- ❖ Rastogi SC, Mendiratta N & Rastogi P. 2004. Bioinformatics: Concepts, Skills and Applications. CBS.

MBB 556 : ENVIRONMENTAL BIOTECHNOLOGY 3+0

Objective

To apprise the students about the role of biotechnology in environment management for sustainable eco-system and human welfare.

Theory

UNIT I

Basic concepts and environmental issues; types of environmental pollution; problems arising from high-input agriculture; methodology of environmental management; air and water pollution and its control; waste water treatment - physical, chemical and biological processes; need for water and natural resource management.

UNIT II

Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents etc; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc); anaerobic processes: digestion, filteration, etc.

UNIT III

Renewable and non-Renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas; microbial hydrogen production; conversion of sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture, etc.

UNIT IV

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

Suggested Readings

- ❖ Evans GM & Furlong JC. 2002. Environmental Biotechnology: Theory and Application. Wiley International.
- ❖ Jordening H-J & Winter J. 2006. Environmental Biotechnology: Concepts and Applications. Wiley-VCH Verlag.

MBB 557 : MOLECULAR CYTOGENETICS 2+1

Theory

UNIT-I

Molecular anatomy of eukaryotic chromosomes: Metaphase chromosome, centromere, kinetochore, telomere and its maintenance, Repeat sequences of centromere and telomeres of chromosome, Heterochromatine and Euchromatain, chromosome banding-basis, techniques and applications.

UNIT-II

Chromosome replication, Artificial chromosomes: synthesis and applications. Organellar genomes: genome organization in chloroplasts and mitochondria, manipulation of organellar genomes and their applications. Genome analysis-significance and uses; Modern methods of genome analysis.

UNIT-III

Location and mapping of genes on chromosomes: genetic, physical and molecular maps, molecular mapping and tagging of genes, Introduction to molecular cytogenetic techniques-*In situ* hybridization, chromosome painting FISH and GISH in plants, their significance and applications in crop improvement, genomic southern hybridization, DNA finger printing repeated nucleotide sequences and simple sequence repeats (SSR)

UNIT-IV

Flow cytometry and chromosome sorting, Automated karyotyping, immunocytochemistry, micro-spectrophotometry, microdissection, microinjection, microcloning, chromosome-based cloning. Cell cycle analysis and control mechanisms; molecular machinery for cell division; molecular analysis of meiosis and recombination, Moelcular cytotgenetics and evolutionary patterns; C- value paradox- DNA content and adaptability. The concept of gene synteny, colinearity among genomes and synteny.

Practicals:

- Study of chromosomes during meiosis
- Staining of metaphase chromosomes – Chromosomal banding – stain with giemsa – fluorescent dye
- Polytene chromosomes – banding – *Chironomus / Drosophila* larva
- Structural abnormalities in chromosomes (Rhoeo – plant mature)
- Induction of polyploidy using colchicines
- Identification of polyploids through cytomorphology, cytometry, DNA Quantification and other molecular techniques
- Demonstration/exploration of FISH, GISH, DNA Finger printing

Suggested Readings

- Alberts et al 1998 Essential Cell Biology Garland
- Alberts et al 2002 Molecular Biology of The Cell Garland
- Bostoc & Sumner 1980 The Eukaryotic Chromosome Elsevier
- Burnham, C.R. 1962 Discussions in Cytogenetics Burgess
- Hamsew & Flavell 1993 The Chromosome Bios
- Hawley & Walker 2003 Advanced Genetic Analysis Blackwell
- Hennig 1987 Structure & Function of Eukaryotic Chromosomes Springer
- Khush,G.S. 1973 Cytogenetics of aneuploids Academic Press
- Lewin 2004 Genes VIII Pearson
- Lodish et al 2004 Molecular Cell Biology Freeman
- Obe & Natarajan 1990 Chromosome aberrations - Basic and Applied Aspects Springer
- Risley 1985 Chromosome Structure and Function Reinhold
- Sumner Chromosomes Blackwell
- Sybenga, J. 1975 Meiotic configurations Springer

MBB 558 : MOLECULAR FARMING 1+1

Theory

Unit I

Definition and scope of molecular farming, Critical needs for vaccine development, Potential to meet critical needs, Scientific back ground on plant-based vaccines. Why GMO for edible vaccines?

Unit-II

Plant based recombinant proteins as valuable drugs, first generation products, and plant patents. Methods of molecular farming, nuclear transformation and Chloroplast transformation. Invention of use for molecular farming.

Unit-III

Molecular farming for protein production, Molecular farming antibodies in plants, Molecular farming for vaccines in plants and Molecular farming product recovery methods.

Unit-IV

Molecular farming information on plant made pharmaceuticals and biopharmaceuticals from genetically engineered plants, Transgenic plants for immunotherapy, Strategy for expression of antigens in plants.

Practicals:

Various tissue culture techniques: Media preparation, preparation of different types of culture including suspension cultures, transformation, regeneration techniques, co-cultivation, selection, confirmation using PCR techniques, extraction of recombinant protein using techniques like Rhizo extraction, SDS –PAGE analysis for quantification.

Reference Books

- Rainer Fischer and Stefan Schillberg, (2004). Molecular farming- Plant made pharmaceuticals and technical proteins. Wiley-VCH Verlag GmbH& Co.KGaA
- Elizabeth E.Hood and John A. Howard (eds.) (2002). Plants as factories for protein production, Kluwer academic publishers P.O. Box 17, 3300 aa Dordrucht, The Netherlands.
- Meran R.L.Owen and Jan Pen (1996). Transgenic plants: A production system for industrial and pharmaceutical proteins. Wiley and sons L.td, Baffin lane, Chichester, West Sussex P.O. 19 UD, England.

MBB 601 : ADVANCES IN PLANT MOLECULAR BIOLOGY 3+0

Objective

To discuss the specialized topics and recent advances in the field of plant molecular biology.

Theory

UNIT I

Arabidopsis inmolecularbiology, Forward andReverse Genetic Approaches, Transcriptional and post-transcriptional regulation of gene expression, isolation of promoters and other regulatory elements.

UNIT II

RNA interference, Transcriptional gene silencing, Transcript and protein analysis, use of transcript profiling to study biological systems.

UNIT III

Hormone regulatory pathways: Ethylene, Cytokinin, Auxin and ABA, SA and JA; ABC Model of Floral Development, Molecular basis of self incompatibility, Regulation of flowering: photoperiod, vernalization, circadian rhythms.

UNIT IV

Molecular biology of abiotic stress responses: Cold, high temperature, sub- mergence, salinity and drought; Molecular Biology of plant-pathogen interactions, molecular biology of *Agrobacterium* Infection, Molecular biology of *Rhizobium* infection (molecular mechanisms in symbiosis), Programmed cell death in development and defense.

Suggested Readings

- Buchanan B, Gruissen W & Jones R. 2000. Biochemistry and Molecular
- Biology of Plants. American Society of Plant Physiologists, USA.

- Lewin B. 2008. Gene IX. Peterson Publications/ Panima.
- Malacinski GM & Freifelder D. 1998. Essentials of Molecular Biology. 3rd Ed. Jones & Bartlett Publ.
- Nelson DL & Cox MM. 2007. Lehninger's Principles of Biochemistry. WH Freeman & Co.
- Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. Molecular Biology of the Gene. 6th Ed. Pearson Education.

MBB 602 : ADVANCES IN GENETIC ENGINEERING 3+0

Objective

To discuss the specialized topics and advances in field of genetic engineering and their application in plant improvement.

Theory

UNIT I

General overview of transgenic plants; Case studies: Genetic engineering of herbicide resistance, Transgenic plants resistant to insects/pests, Genetic engineering of abiotic stress tolerance, Engineering food crops for quality, Genetically engineered pollination control, Induction of male sterility in plants.

UNIT II

Molecular farming of plants for applications in veterinary and human medicine systems: Boosting heterologous protein production in transgenics, Rapid production of specific vaccines, High-yield production of therapeutic proteins in chloroplasts.

UNIT III

Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement; Regulated and tissue-specific expression of transgenes for crop improvement; Gene stacking; Pathway engineering; Marker-free transgenic development strategies; High throughput phenotyping of transgenic plants.

UNIT IV

Field studies with transgenic crops; Environmental issues associated with transgenic crops; Food and feed safety issues associated with transgenic crops; Risk assessment of transgenic food crops.

Suggested Readings

- Christou P & Klee H. 2004. Handbook of Plant Biotechnology. John Wiley & Sons.
- Specific journals mentioned later.

MBB 603 : ADVANCES IN MICROBIAL BIOTECHNOLOGY 3+0

Objective

To discuss specialized topics about industrially important microorganisms.

Theory

UNIT I

Fermentative metabolism and development of bioprocessing technology, processing and production of recombinant products; isolation, preservation and improvement of industrially important microorganisms.

UNIT II

Immobilization of enzymes and cells; Batch, plug flow and chemostate cultures; Computer simulations; Fed-batch and mixed cultures; Scale-up principles; Down stream processing etc.

UNIT III

Current advances in production of antibiotics, vaccines, and biocides; Steroid transformation; Bioreactors; Bioprocess engineering; Production of non-microbial origin products by genetically engineered microorganisms.

UNIT IV

Concept of probiotics and applications of new tools of biotechnology for quality feed/food production; Microorganisms and proteins used in probiotics; Lactic acid bacteria as live vaccines; Factors affecting delignification; Bioconversion of substrates, anti-nutritional factors present in feeds; Microbial detoxification of aflatoxins; Single cell protein, Bioinsecticides; Biofertilizers; Recent advances in microbial biotechnology.

Suggested Readings

- Specific journals and published references.

MBB 604 : ADVANCES IN CROP BIOTECHNOLOGY 3+0

Objective

To discuss specialized topics on the application of molecular tools in breeding of specific crops.

Theory

UNIT I

Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available molecular marker, transformation and genomic tools for crop improvement.

UNIT II

Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc) and biotic (insect pests, fungal, viral and bacterial diseases, weeds, etc) stresses; Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, mineral nutrients, etc); edible vaccines, etc.

UNIT III

Molecular breeding: constructing molecular maps; integrating genetic, physical and molecular maps; diversity assessment and phylogenetic analysis; molecular tagging of genes/traits; selected examples on marker- assisted selection of qualitative and quantitative traits.

UNIT IV

Discussion on application of molecular, transformation and genomic tools for the genetic enhancement in some major field crops such as rice, wheat, cotton, maize, soybean, oilseeds, sugarcane etc.

Suggested Readings

- Specific journals and published references.

MBB 605 : ADVANCES IN FUNCTIONAL GENOMICS AND PROTEOMICS 2+0

Objective

To discuss recent advances and applications of functional genomics and proteomics in agriculture, medicine and industry.

Theory

UNIT I

Genome sequencing and functional genomics; Human, animal, plant, bacterial and yeast genome projects; genome annotation; *ab initio* gene discovery; functional annotation and gene family clusters; etc.

UNIT II

Functional analysis of genes; RNA-mediated interference; gene knockoffs; Gene traps/ T-DNA insertion lines; homologous recombination; microarray profiling; SAGE; SNPs/variation; yeast-two hybrid screening; gene expression and transcript profiling; EST contigs; EcoTILLING; allele/gene mining; synteny and comparative genomics; Genome evolution, speciation and domestication etc.

UNIT II

Proteomics: protein annotation; protein separation and 2D PAGE; mass spectroscopy; protein microarrays; protein interactive maps; structural proteomics: protein structure determination, prediction and threading, software and data analysis/ management, etc.

UNIT IV

Discussion on selected papers on functional genomics, proteomics, integrative genomics etc.

Suggested Readings

- Specific journals and published references.

MBB 606 : COMMERCIAL PLANT TISSUE CULTURE 2+0

Objective

To discuss the commercial applications of plant tissue culture in agriculture, medicine and industry.

Theory

UNIT I

Micropropagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing.

UNIT II

Production of useful compounds via biotransformation and secondary metabolite production: suspension cultures, immobilization, examples of chemicals being produced for use in pharmacy, medicine and industry.

UNIT III

Value-addition by transformation; development, production and release of transgenic plants; patent, bio-safety, regulatory, environmental and ethic issues; management and commercialization.

UNIT IV

Some case studies on success stories on commercial applications of plant tissue culture. Visitstosometissueculturebasedcommercial units/industries.

Suggested Readings

- Specific journals and published references.

MBB 607 : ADVANCES IN ANIMAL BIOTECHNOLOGY 2+0

Objective

Intended to provide cutting edge knowledge on advances in different areas of animal biotechnology.

Theory

UNIT I

Advances in animal cell culture technology, suspension culture technology, advances in commercial scale productions of mammalian cells.

UNIT II

Advances in cell cloning and cell hybridization, advances in monoclonal antibody production technology, Advances in diagnostic technology, Computational vaccinology, reverse genetics based vaccines.

UNIT III

Advances in embryo manipulation, knock out and knock in technology, advances in animal cloning technology, stem cell technology, Advances in development of animal models for human diseases using transgenic animal technology.

UNIT IV

Advances in genetic basis for animal disease resistance, Molecular methods for animal forensics, Advances in animal genomics, proteomics,

Suggested Readings

- Selected articles from journals.

GENETICS AND PLANT BREEDING

GP 501 : PRINCIPLES OF GENETICS 2+1

Objective

This course is aimed at understanding the basic concepts of genetics, helping students to develop their analytical, quantitative and problem- solving skills from classical to molecular genetics.

Theory

UNIT I

Beginning of genetics; Cell structure and cell division; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance.

UNIT II

Multiple alleles,Gene interactions. Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

UNIT III

Population - Mendelian population – Random mating population - Frequencies of genes and genotypes-Causes of change: Hardy-Weinberg equilibrium.

UNIT IV

Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis.

UNIT V

Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters.

UNIT VI

Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression. Gene regulation in eukaryotes, RNA editing.

UNIT VII

Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR- based cloning, positional cloning; Nucleic acid hybridization and immuno- chemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).

UNIT VIII

Genomics and proteomics; Functional and pharmacogenomics; Metagenomics.

UNIT IX

Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts.

UNIT X

Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics.

Practical

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification - Electrophoresis – basic principles and running of amplified DNA - Extraction of proteins and isozymes – use of *Agrobacterium* mediated method and Biolistic gun; practical demonstrations - Detection of transgenes in the exposed plant material; visit to transgenic glasshouse and learning the practical considerations.

Suggested Readings

- Gardner EJ & Snustad DP. 1991. Principles of Genetics. John Wiley & Sons.
- Klug WS & Cummings MR. 2003. Concepts of Genetics. Peterson Edu.
- Lewin B. 2008. Genes IX. Jones & Bartlett Publ.
- Russell PJ. 1998. Genetics. The Benzamin/Cummings Publ. Co.

- Snustad DP & Simmons MJ. 2006. Genetics. 4th Ed. John Wiley & Sons. Strickberger MW. 2005. Genetics (III Ed). Prentice Hall, New Delhi, India
- Tamarin RH. 1999. Principles of Genetics. Wm. C. Brown Publs.
- Uppal S, Yadav R, Subhadra & Saharan RP. 2005. Practical Manual on
- Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar.

GP 502 : PRINCIPLES OF CYTOGENETICS 2+1

Objective

To provide insight into structure and functions of chromosomes, chromosome mapping, polyploidy and cytogenetic aspects of crop evolution.

Theory

UNIT I

Architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; Artificial chromosome construction and its uses; Special types of chromosomes.

UNIT II

Chromosomal theory of inheritance – Cell Cycle and cell division – mitosis and meiosis; Differences, significance and deviations – Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over- mechanisms and theories of crossing over- recombination models, cytological basis, - Variation in chromosome structure: Evolutionary significance - Introduction to techniques for karyotyping; Chromosome banding and painting - *in situ* hybridization and various applications.

UNIT III

Structural and Numerical variations of chromosomes and their implications

- Symbols and terminologies for chromosome numbers - euploidy - haploids, diploids and polyploids ; Utilization of aneuploids in gene location - Variation in chromosome behaviour - somatic segregation and chimeras – endomitosis and somatic reduction ; Evolutionary significance of chromosomal aberrations - balanced lethals and chromosome complexes.

UNIT IV

Inter-varietal chromosome substitutions; Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids vs allopolyploids –- Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer – Alien addition and substitution lines – creation and utilization; Apomixis - Evolutionary and genetic problems in crops with apomixes.

UNIT V

Reversion of autopolyploids to diploids; Genome mapping in polyploids - Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale and brassica) – Hybrids between species with same chromosome number, alien translocations - Hybrids between species with different chromosome number; Gene transfer using amphidiploids - Bridge species.

UNIT VI

Fertilization barriers in crop plants at pre-and postfertilization levels- *In vitro* techniques to overcome the fertilization barriers in crops; Chromosome manipulations in wide hybridization ; case studies – Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical

Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. - Microscopy: various types of microscopes, - Observing sections of specimen using Electron microscope; Preparing specimen for observation - Fixative preparation and fixing specimen for light microscopy studies in cereals - Studies on the course of mitosis in wheat, pearl millet - Studies on the course of mitosis in onion and *Aloe vera* **-** Studies on the course of meiosis in cereals, millets and pulses - Studies on the course of meiosis in oilseeds and forage crops - Using micrometers and studying the pollen grain size in various crops -Various methods of staining and preparation of temporary and permanent slides - Pollen germination *in vivo* and *in vitro;* Microtomy and steps in microtomy; Agents employed for the induction of various ploidy levels; Solution

preparation and application at seed, seedling level - Identification of polyploids in different crops - Induction and identification of haploids; Anther culture and Ovule culture - Morphological observations on synthesized autopolyploids - Observations on C-mitosis, learning on the dynamics of spindle fibre assembly - Morphological observations on alloployploids - Morphological observations on aneuploids
- Cytogenetic analysis of interspecific and intergeneric crosses - Maintenance of Cytogenetic stocks and their importance in crop breeding - Various ploidy levels due to somaclonal variation ; Polyploidy in ornamental crops. -Fluorescent *in situ* hybridization (FISH)- Genome *in situ* hybridization GISH.

Suggested Readings

- Becker K & Hardin. 2004. The World of Cell. 5th Ed. Pearson Edu.
- Carroll M. 1989. Organelles. The Guilford Press.
- Charles B. 1993. Discussions in Cytogenetics. Prentice Hall.
- Darlington CD & La Cour LF. 1969. The Handling of Chromosomes. Georger Allen & Unwin Ltd.
- Elgin SCR. 1995. Chromatin Structure and Gene Expression. IRL Press.
- Gray P. 1954. The Mirotomist's Formulatory Guide. The Blakiston Co.
- Gupta PK & Tsuchiya T. 1991. Chromosome Engineering in Plants:Genetics, Breeding and Evolution. Part A. Elsevier.
- Gupta PK. 2000. Cytogenetics. Rastogi Publ.
- Johannson DA. 1975. Plant Microtechnique. McGraw Hill.
- Karp G. 1996. Cell and Molecular Biology: Concepts and Experiments.John Wiley & Sons.
- Khush GS. 1973. Cytogenetics of Aneuploids. Academic Press.
- Sharma AK & Sharma A. 1988. Chromosome Techniques: Theory and Practice. Butterworth.
- Sumner AT. 1982. Chromosome Banding. Unwin Hyman Publ.
- Swanson CP. 1960. Cytology and Cytogenetics. Macmillan & Co.

GP 503 : PRINCIPLES OF PLANT BREEDING 2+1

Objective

To impart theoretical knowledge and practical skills about plant breeding objectives, modes of reproduction and genetic consequences, breeding methods for crop improvement.

Theory

UNIT I

History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants- Centres of Origin-biodiversity and its significance.

UNIT II

Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype- environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding; Plant introduction and role of plant genetic resources in plant breeding.

UNIT III

Self-incompatibility and male sterility in crop plants and their commercial exploitation.

UNIT III

Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops (diallel selective mating approach).

UNIT IV

Breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter- population improvement and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.

UNIT V

Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection.

UNIT VI

Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding.

UNIT VII

Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses.

UNIT VIII

Cultivar development- testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical

Floral biology in self and cross pollinated species, selfing and crossing techniques. Selection methods in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance; Maintenance of experimental records; Learning techniques in hybrid seed production using male-sterility in field crops.

Suggested Readings

- Allard RW. 1981. Principles of Plant Breeding. John Wiley & Sons.
- Chopra VL. 2001. Breeding Field Crops. Oxford & IBH.
- Chopra VL. 2004. Plant Breeding. Oxford & IBH.
- Gupta SK. 2005. Practical Plant Breeding. Agribios.
- Pohlman JM & Bothakur DN. 1972. Breeding Asian Field Crops. Oxford & IBH.
- Roy D. 2003. Plant Breeding, Analysis and Exploitation of Variation.Narosa Publ. House.
- Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
- Simmonds NW. 1990. Principles of Crop Improvement. English Language Book Society.
- Singh BD. 2006. Plant Breeding. Kalyani.
- Singh P. 2002. Objective Genetics and Plant Breeding. Kalyani.
- Singh P. 2006. Essentials of Plant Breeding. Kalyani.
- Singh S & Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding. CBS.

GP 504 : PRINCIPLES OF QUANTITATIVE GENETICS 2+1

Objective

To impart theoretical knowledge and computation skills regarding component of variation and variances, scales, mating designs and gene effects.

Theory

UNIT I

Mendelian traits *vs* polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions; Nature of gene action - additive, dominance, epistatic and linkage effects.

UNIT II

Principles of Anaylis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance.

UNIT III

Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D^2 analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance.

UNIT IV

Generation mean analysis; Mating designs- Diallel, partial diallel, line x tester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for GxE analysis and stability parameters; AMMI analysis – principles and interpretation.

UNIT V

QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic analysis; Marker assisted selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.

Practical

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D2 analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II - Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and interpretation of results - Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression - Generation mean analysis: Analytical part and Interpretation - Estimation of different types of gene actions.
Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes.

Suggested Readings

- Bos I & Caligari P. 1995. Selection Methods in Plant Breeding. Chapman & Hall.
- Falconer DS & Mackay J. 1998. Introduction to Quantitative Genetics. Longman.
- Mather K & Jinks JL. 1971. Biometrical Genetics. Chapman & Hall.
- Mather K & Jinks JL. 1983. Introduction to Biometrical Genetics. Chapman & Hall.
- Nadarajan N & Gunasekaran M. 2005. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani.
- Naryanan SS & Singh P. 2007. Biometrical Techniques in Plant Breeding. Kalyani.
- Singh P & Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. Kalyani.
- Singh RK & Choudhary BD. 1987. Biometrical Methods in Quantitative Genetics. Kalyani.
- Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.
- Wricke G & Weber WE. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.

GP 505 : MUTAGENESIS AND MUTATION BREEDING 1+1

Objective

To impart the knowledge about general principles of radiation and various tests/methods for detection of radiation effects on the living cells, genetic risks involved and perspectives of advances made.

Theory

UNIT I

Mutation and its history - Nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations - Detection of mutations in lower and higher organisms – paramutations.

UNIT II

Mutagenic agents: physical -- Radiation types and sources: Ionising and non-ionizing radiations *viz*., X rays, γ rays, , □ and β particles, protons, neutrons and UV rays - Radiobiology: mechanism of action of various radiations (, photoelectric absorption, Compton scattering and pair production) and their biological effects –RBE and LET relationships.

UNIT III

Effect of mutations on DNA - Repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects - Dosimetry - Objects and methods of treatment - Factors influencing mutation: dose rate, acute *vs* chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects - Radiation sensitivity and modifying factors: External and internal sources- Oxygen, water content, temperature and nuclear volume.

UNIT IV

Chemical mutagens- Classification - Base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action - Dose determination and factors influencing chemical mutagenesis - Treatment methods using physical and chemical mutagens - Combination treatments; Other causes of mutation - direct and indirect action, comparative evaluation of physical and chemical mutagens.

UNIT V

Observing mutagen effects in M_1 generation: plant injury, lethality, sterility, chimeras *etc*., - Observing mutagen effects in M_2 generation - Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations - Mutations in traits with continuous variation.

UNIT VI

Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage *etc*. - Individual plant based mutation analysis and working out effectiveness and efficiency in M_3 generation - Comparative evaluation of physical and chemical mutagens for creation of variability in the same species – Case studies.

UNIT VII

Use of mutagens in creating oligogenic and polygenic variations – Case studies - *In vitro* mutagenesis – callus and pollen irradiation; Handling of segregating genrations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement,etc) in different crops- Procedures for micro- mutations breeding/polygenic mutations- Achievements of mutation breeding- varieties released across the world- Problems associated with mutation breeding.

UNIT VIII

Use of mutagens in genomics, allele mining, TILLING.

Practical

Learning the precautions on handling of mutagens; Dosimetry - Studies of different mutagenic agents: Physical mutagens - Studies of different mutagenic agents: Chemical mutagens - Learning on Radioactivity – Production of source and isotopes at BRIT, Trombay - Learning about gamma chamber; Radiation hazards - Monitoring – safety regulations and safe transportation of radioisotopes - Visit to radio isotope laboratory ; learning on safe disposal of radioisotopes - Hazards due to chemical mutagens - Treating the plant propagules at different doses of physical and chemical mutagens - Learning combined mutagenic treatments; Raising the crop for observation - Mutagenic effectiveness and efficiency; Calculating the same from earlier literature - Study of M1 generation – Parameters to be observed; Study of M_2 generation – Parameters to be observed; Mutation breeding in cereals and pulses – Achievements made and an analysis - Mutation breeding in oilseeds and cotton – Achievements and opportunities - Mutation breeding in forage crops and vegetatively propagated crops; Procedure for detection of mutations for polygenic traits in M_2 and M_3 generations.

Suggested Readings

- Alper T. 1979. Cellular Radiobiology. Cambridge Univ. Press, London.
- Chadwick KH & Leenhouts HP. 1981. The Molecular Theory of Radiation Biology. Springer-Verlag.
- Cotton RGH, Edkin E & Forrest S. 2000. Mutation Detection: A Practical Approach. Oxford Univ. Press.
- International Atomic Energey Agency. 1970. Manual on Mutation Breeding. International Atomic Energey Agency, Vienna, Italy.
- Singh BD. 2003. Genetics. Kalyani.

❖ Strickberger MW. 2005. Genetics. 3rd Ed. Prentice Hall.

GP 506 : POPULATION GENETICS 2+1

Objective

To impart knowledge on structure, properties and their breeding values of different population.

Theory

UNIT I

Population - Properties of population - Mendelian population – Genetic constitution of a population through time, space, age structure etc. Mating systems - Random mating population - Frequencies of genes and genotypes-Causes of change: population size, differences in fertility and viability, migration and mutation.

UNIT II

Hardy-Weinberg equilibrium - Hardy-Weinberg law - Proof - Applications of the Hardy-Weinberg law - Test of Hardy-Weinberg equilibrium - Mating frequencies - Non-dominance - Codominance - Snyder's ratio, importance and its effect over random mating in succeeding generations.

UNIT III

Multiple alleles - More than one locus - Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations - Changes of gene frequency - Migration – Mutation - Recurrent and non- recurrent - Selection - Balance between selection and mutation - Selection favouring heterozygotes - Overdominance for fitness.

UNIT IV

Non random mating: selfing –inbreeding coefficient - panmictic index – sibmating - Assortative mating and disassortative mating - Pedigree populations and close inbreeding - Estimation of selection - Estimation of disequilibrium - Estimation of linkage - Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops.

UNIT V

Gene substitution and average effects; Breeding value- Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis- Adapative organization of gene pools, Polymorphism- Balanced and Non-balanced polymorphism, heterozygous advantage- Survival ofrecessive and deleterious alleles in populations.

Practical

Genetic exercise on probability**;** Estimation of gene frequencies; Exercises on factors affecting gene frequencies; Estimation of average affect of gene substitution and breeding value; Exercises on inbreeding and linkage disequilibrium- Cavalli's joint scaling test; Exercises of different mating designs; Estimation of different population parameters from experimental data; Measurement ofgenotype-environment interaction; Genetic divergence.

Suggested Readings

❖ Chawla V & Yadava RK. 2006. Principles of Population Genetics - A Practical Manual. Dept. of Genetics, CCS HAU Hisar.
❖ Falconer DS & Mackay J.1996. Introduction to Quantitative Genetics. Longman.
❖ Jain JP, Jain J & Parbhakaran, VT. 1992. Genetics of Populations. South Asia Books.
❖ Li CC. 1955. Population Genetics. The Univ. of Chicago Press.
❖ Mather K & Jinks JL. 1982. Biometrical Genetics. Chapman & Hall.
❖ Sorrens D & Doniel G. 2007. Methods in Quantitative Genetics. Series: Statistics for Biology and Health. Likelihood.
❖ Tomar SS. 1992. Text Book of Population Genetics. Universal Publication.

GP 507 ; HETEROSIS BREEDING 2+1

Objective

To provide understanding about mechanisms of heterosis and its exploitation for yield improvement through conventional and biotechnological approaches.

Theory

UNIT I

Historical aspect of heterosis - Nomenclature and definitions of heterosis - Heterosis in natural population and inbred population; Evolutionary aspects
- Genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops crops.

UNIT II

Pre Mendelian and Post-Mendelian ideas - Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; - Evolutionary concepts of heterosis.

UNIT III

Prediction of heterosis from various crosses- Inbreeding depression, frequency of inbreeding and residual heterosis in F_2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies. - Relationship between genetic distance and expression of heterosis – case studies; Divergence and Genetic Distance analyses- morphological and molecular genetic distance in predicting heterosis, Development of heterotic pools in germplasm/genetic stocks and inbreds, their improvement for increasing heterosis.

UNIT IV

Types of male sterility and use in heterosis breeding; Maintenance, transfer and restoration of different types of male sterility; Use of self- incompatibility in development of hybrids; Hybrid seed production system:
3-line, 2-line and 1-line system; Development of inbreds and parental lines-
A, B and R lines – functional male sterility; Commercial exploitation of heterosis- maintenance breeding of parental lines in hybrids.

UNIT V

Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonally propagated crops; Male sterile line creation and diversification in self pollinated, cross pollinated and asexually propagated crops; problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid.

UNIT VI

Organellar heterosis and complementation - Creation of male sterility through genetic engineering and its exploitation in heterosis.

UNIT VII

Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops.

Practical

Selection indices and selection differential – Calculations and interpretations - Male sterile line characterization in millets; Using morphological descriptors; Restorer line identification and diversification of male sterile sources - Male sterile line creation in dicots comprising oilseeds, pulses and cotton ; problems in creation of CGMS system; Ways of overcoming them - Male sterile line creation, diversification and restoration in forage crops; Understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated crops - Estimation from the various models for heterosis parameters - Hybrid seed production in field crops – an account on the released hybrids; their potential; Problems and ways of overcoming it; hybrid breeding at National and International level; Opportunities ahead.

Suggested Readings

- Proceedings of Genetics and Exploitation of Heterosis in Crops - An International Symposium CIMMYT, 1998.
- Akin E. 1979. The Geometry of Population Genetics. Springer-Verlag.
- Ben Hiu Lin. 1998. Statistical Genomics – Linkage, Mapping and QTL Analysis. CRC Press.
- De Joung G. 1988. Population Genetics and Evolution. Springer-Verlag.
- Hartl DL. 2000. A Primer of Population Genetics. 3rd Ed. Sinauer Assoc.
- Mettler LE & Gregg TG. 1969. Population Genetics and Evolution. Prentice-Hall.
- Montgomery DC. 2001. Design and Analysis of Experiments. 5th Ed., Wiley & Sons.

- Richards AJ. 1986. Plant Breeding Systems. George Allen & Unwin.
- Srivastava S & Tyagi R. 1997. Selected Problems in Genetics. Vols. I, II.Anmol Publ.

GP 508 : CELL BIOLOGY AND MOLECULAR GENETICS 2+1

Objective

To impart knowledge in theory and practice about cell structure, organelles and their functions, molecules like proteins and nucleic acids.

Theory

UNIT I

Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells, macromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular Organelles – nucleus, plastids- chloro/chromoplast, mitochondria endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes.

UNIT II

Bioenergetics; Ultrastructure and function of mitochondria and biological membranes; Chloroplast and other photosynthetic organelles; Interphase nucleus- Structure and chemical composition; Cell division and physiology of cell division.

UNIT III

Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, DNA transcription and its regulation – Transcription factors and their role; Genetic code, regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes, t-RNAs and translational factors.

UNIT IV

Transposable elements; Mechanisms of recombination in prokaryote; DNA organization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; organelle genomes; Gene amplification and its significance; Proteomics and protein-protein interaction; Signal transduction; Genes in development; Cancer and cell aging.

Practical

Morphological and Gram staining of natural bacteria; Cultivation of bacteria in synthetic medium; Determination of growth rate and doubling time of bacterial cells in culture; Demonstration of bacteriophage by plaque assay method; Determination of soluble protein content in a bacterial culture. Isolation, purification and raising clonal population of a bacterium; Biological assay of bacteriophage and determination of phage population in lysate; Study oflytic cycle of bacteriophage by one step growth experiment; determination of latent period and burst size of phages per cell; Quantitative estimation of DNA, RNA and protein in an organism; Numericals: problems and assignments.

Suggested Readings

- Bruce A.2004. Essential Cell Biology. Garland.
- Karp G.2004. Cell and Molecular Biology: Concepts and Experiments. John Wiley.
- Klug WS & Cummings MR 2003. Concepts of Genetics. Scot, Foreman & Co.
- Lewin B. 2008. IX Genes. John Wiley & Sons
- Lodish H, Berk A & Zipursky SL. 2004. Molecular Cell Biology. 5th Ed. WH Freeman.
- Nelson DL & Cox MM. 2005. Lehninger's Principles of Biochemistry. WH Freeman & Co.
- Russell PJ. 1996. Essential Genetics. Blackwell Scientific Publ.
- Schleif R.1986. Genetics and Molecular Biology. Addison-Wesley Publ. Co.

GP 509 : BIOTECHNOLOGY FOR CROP IMPROVEMENT 2+1

Objective

To impart knowledge and practical skills to use biotechnological tools in crop improvement.

Theory

UNIT I

Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding.

UNIT II

Tissue culture- History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.

UNIT III

Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.), mapping populations (F_2s, back crosses, RILs, NILs and DH).

UNIT IV

Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding.

UNIT V

Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression, Generation of EDVs.

UNIT VI

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc. Commercial releases.

UNIT VII

Biotechnology applications in male sterility/hybrid breeding, molecular farming.

UNIT VIII

MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights

UNIT IX

Bioinformatics & Bioinformatics tools.

UNIT X

Nanotechnology and its applications in crop improvement programmes.

Practical

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants ; observations on the contaminants occurring in media – interpretations - Inoculation of explants; Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial micropropagation unit. Transformation using *Agrobacterium* strains, GUS assay in transformed cells / tissues. DNA isolation, DNA purity and quantification tests, gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship, construction of genetic linkage maps using computer software.

Suggested Readings

- Chopra VL & Nasim A. 1990. Genetic Engineering and Biotechnology: Concepts, Methods and Applications. Oxford & IBH.
- Gupta PK. 1997. Elements of Biotechnology. Rastogi Publ.
- Hackett PB, Fuchs JA & Messing JW. 1988. An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation. 2nd Ed. Benjamin Publ. Co.
- Sambrook J & Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.
- Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani.

GP 510 : BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE 2+1

Objective

To apprise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress resistant varieties.

Theory

UNIT I

Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses – major pests and diseases of economically important crops - Concepts in insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defense mechanisms against viruses and bacteria.

UNIT II

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants. Quantitative resistance/Adult plant resistance and Slow rusting resistance - Classical and molecular breeding methods - Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies.

UNIT III

Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data - Gene pyramiding methods and their implications.

UNIT IV

Classification of abiotic stresses - Stress inducing factors –moisture stress/drought and water logging & submergence; Acidity, salinity/alkalinity/sodicity; High/low temperature, wind, etc. Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

UNIT V

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging & submergence, high and low/freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton etc; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in soil, water and environment.

UNIT VI

Exploitation of wild relatives as a source of resistance to biotic and abiotic factors in major field crops - Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitnases and Bt for diseases and insect pest management- Achievements.

Practical

Phenotypic screening techniques for sucking pests and chewing pests – Traits to be observed at plant and insect level - Phenotypic screening techniques for nematodes and borers; Ways of combating them; Breeding strategies - Weeds – ecological, environmental impacts on the crops; Breeding for herbicide resistance - Evaluating the available populations like RIL, NIL etc. for pest resistance; Use of standard MAS procedures - Phenotypic screening methods for diseases caused by fungi and bacteria; Symptoms and data recording; use of MAS procedures - Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation - Screening crops for drought and flood resistance; factors to be considered and breeding strategies - Screening varieties of major crops for acidity and alkalinity- their effects and breeding strategies; Understanding the climatological parameters and predisposal of biotic and abiotic stress factors- ways of combating them.

Suggested Readings

- Blum A. 1988. Plant Breeding for Stress Environments. CRC Press.
- Christiansen MN & Lewis CF. 1982. Breeding Plants for Less Favourable Environments. Wiley International.

- Fritz RS & Simms EL. (Eds.). 1992. Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics. The University of Chicago Press.
- Li PH & Sakai A. 1987. Plant Cold Hardiness. Liss, New York
- Luginpill P. 1969. Developing Resistant Plants - The Ideal Method of Controlling Insects. USDA, ARS, Washington DC.
- Maxwell FG & Jennings PR. (Eds.). 1980. Breeding Plants Resistant to Insects. John Wiley & Sons.
- Painter RH. 1951. Insect Resistance in Crop Plants. MacMillan, New York.
- Russel GE. 1978. Plant Breeding for Pest and Disease Resistance.Butterworths.
- Sakai A & Larcher W. 1987. Frost Survival in Plants. Springer-Verlag.
- Turener NC & Kramer PJ. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons.
- van der Plank JE. 1982. Host-Pathogen Interactions in Plant Disease. Academic Press.

GP 511 : BREEDING CEREALS, FORAGES AND SUGARCANE 2+1

Objective

To provide insight into recent advances in improvement of cereals and forage crops and sugarcane using conventional and modern biotechnological approaches.

Theory

UNIT I

Rice: Evolution and distribution of species and forms - wild relatives and germplasm; Genetics – cytogenetics and genome relationship - Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc.*
– Hybrid rice breeding- potential and outcome - Aerobic rice, its implications and drought resistance breeding.

UNIT II

Wheat: Evolution and distribution of species and forms - wild relatives and germplasm; cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance, exploitation of heterosis etc; Sorghum: Evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship - Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc; Pearl millet: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc.

UNIT III

Maize: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc - QPM and Bt maize – strategies and implications - Heterosis breeding attempts taken in Sorghum, Pearl Millet and Maize; Minor millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - Minor millets: breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc.

UNIT IV

Sugarcane: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc - Forage grasses: Evolution and distribution of species and forms - Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance etc., synthetics, composites and apomixes.

UNIT V

Forage legumes: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc - Tree fodders: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc*, palatability studies.

UNIT VI

Distinguishing features of popular released varieties in Rice and Sorghum - Wheat, Pearl millet, Maize and other millets - Sugarcane, forage grasses and legumes and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production.

Practical

Floral biology – emasculation - pollination techniques ; Study of range of variation for yield and yield components – Study of segregating populations and their evaluation - Trait based screening for stress resistance in crops of importance– Use of descriptors for cataloguing Germplasm maintenance; learning on the Standard Evaluation System (SES) and descriptors; Use of softwares for database management and retrieval.Practical learning on the cultivation of fodder crop species on sewage water; analysing them for yield components and palatability; Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes; Visit to animal feed producing factories, learning the practice of value addition; visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.

Suggested Readings

- Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
- Bahl PN & Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I. Pulses and Oilseeds. Oxford & IBH.
- Chandraratna MF. 1964. Genetics and Breeding of Rice. Longmans.
- Chopra VL & Prakash S. 2002. Evolution and Adaptation of Cereal Crops. Oxford & IBH.
- Gill KS. 1991. Pearl Millet and its Improvement. ICAR.
- IRRI. 1964. Rice Genetics and Cytogenetics. Elsevier.
- IRRI. 1986. Rice Genetics. Proc. International Rice Genetics Symposium.
- IRRI, Los Banos, Manila, Philippines.
- IRRI. 1991. Rice Genetics II. Proc. International Rice Genetics Symposium.
- IRRI, Los Banos, Manila, Philippines.
- IRRI. 1996. Rice Genetics III. Proc. International Rice Genetics Symposium.
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- IRRI. 2000. Rice Genetics IV. Proc. International Rice Genetics Symposium.
- IRRI, Los Banos, Manila, Philippines.
- Jennings PR, Coffman WR & Kauffman HE. 1979. Rice Improvement. IRRI, Los Banos, Manila, Philippines.
- Kannaiyan S, Uthamasamy S, Theodore RK & Palaniswamy S. 2002. New Dimensions and Approaches for Sustainable Agriculture. Directorate of Extension Education, TNAU, Coimbatore.
- Murty DS, Tabo R & Ajayi O. 1994. Sorghum Hybrid Seed Production and Management. ICRISAT, Patancheru, India. Nanda JS. 1997. Manual on Rice Breeding. Kalyani.
- Ram HH & Singh HG. 1993. Crop Breeding and Genetics. Kalyani.
- Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.
- Slafer GA. (Ed.). 1994. Genetic Improvement of Field Crops. Marcel Dekker.
- Walden DB. 1978. Maize Breeding and Genetics. John Wiley & Sons.

GP 512 : BREEDING LEGUMES, OILSEEDS AND FIBRE CROPS 2+1

Objective

To provide insight into recent advances in improvement of legumes, oilseeds and fibre crops using conventional and modern biotechnological approaches.

Theory

UNIT I

Pigeonpea: Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship; Morphological and molecular descriptors used

for differentiating the accessions; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc* - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at ICRISAT and other Institutes.

UNIT II

Chickpea: Evolution and distribution of species and forms - Wild relatives and germplasm - cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Protein quality improvement; Conventional and modern plant breeding approaches, progress made - Breeding for anti nutritional factors.

UNIT III

Other pulses: Greengram, blackgram, fieldpea, lentil,, lathyrus, cowpea, lablab, mothbean: Evolution, cytogenetics and genome relationship; Learning the descriptors; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

UNIT IV

Groundnut: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Pod and kernel characters; Breeding objectives- yield, quality characters, biotic and abiotic stress etc.

UNIT V

Rapeseed and Mustard: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc; Oil quality – characteristics in different oils; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

UNIT VI

Soybean: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc. - Oil quality – characteristics; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

UNIT VII

Other oilseed crops: Sunflower, sesame, safflower, niger: Evolution and
distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress; Sunflower: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, hybrid sunflower, constraints and achievements.

UNIT VIII

Castor: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, breeding objectives- yield, quality characters, biotic and abiotic stress *etc* - Hybrid breeding in castor – opportunities, constraints and achievements.

UNIT IX

Cotton: Evolution of cotton; Breeding objectives- yield, quality characters, biotic and abiotic stress etc; Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton. Jute: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress etc; Mesta and minor fibre crops: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress etc.

UNIT X

Distinguishing features of the released varieties in pulses, oilseeds and cotton; Maintenance of seed purity and seed production.

Practical

Use of descriptors for cataloguing – Floral biology - emasculation – pollination techniques; Study of range of variation for yield and yield components - Study of segregating populations in Redgram, Greengram, Blackgram and other pulse crops; Attempting crosses between blackgram and greengram. Use of descriptors for cataloguing – Floral biology, emasculation, pollination techniques of oilseed crops like Sesame, Groundnut, Sunflower and Castor, Cotton: Use of descriptors for cataloguing – Floral biology - Learning on the crosses between different species - Cotton: Study of range of variation for yield and yield components - Study of segregating populations - evaluation - Trait based screening for stress resistance -

Cotton fibre quality evaluation – conventional and modern approaches; analysing the lint samples of different species, interspecific and interracial derivatives for fibre quality and interpretation –Development and maintenance of male sterile lines Evaluation of cotton cultures of different species for insect and disease resistance – Learning the mechanisms of resistance, quantifying the resistance using various parameters; Evaluating the germplasm of cotton for yield, quality and resistance parameters – learning the procedures on development of Bt cotton - Visit to Cotton Technology Laboratory and Spinning Mills – Learning on cotton yarn production, its quality evaluation and uses.

Suggested Readings

- Agarwal RL. 1996. Identifying Characteristics of Crop Varieties. Oxford & IBH.
- Bahl PN & Salimath PM. 1996. Genetics, Cytogenetics and Breeding of Crop Plants. Vol. I. Pulses and Oilseeds. Oxford & IBH.
- Chahal GS & Ghosal SS. 2002. Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches. Narosa Publ.
- Chopra VL. 1997. Plant Breeding. Oxford & IBH.
- Nath V & Lal C. 1995. Oilseeds in India. Westvill Publ. House.
- Nigam J. 1996. Genetic Improvement of Oilseed Crops. Oxford & IBH.
- Ram HH & Singh HG. 1993. Crop Breeding and Genetics. Kalyani.
- Singh DP. 1991. Genetics and Breeding of Pulse Crops. Kalyani.
- Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994. Crop Breeding in India. International Book Distributing Co.
- Smartt J. 1994. The Groundnut Crop - a Scientific Basis for Improvement. Chapman & Hall.

GP 513 : BREEDING FOR QUALITY TRAITS 2+1

Objective

To provide insight into recent advances in improvement of quality traits in rice, millets, legumes, oilseeds and forage crops and for physiological efficiency using conventional and modern biotechnological approaches.

Theory

UNIT I

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Nutritional improvement - A human perspective - Breeding for grain quality parameters in rice and its analysis - Golden rice and aromatic rice – Breeding strategies, achievements and application in Indian context - Molecular basis of quality traits and their manipulation in rice - Post harvest manipulation for quality improvement.

UNIT II

Breeding for baking qualities in wheat; Characters to be considered and breeding strategies - Molecular and cytogenetic manipulation for quality improvement in wheat - Breeding for quality improvement in barley and oats.

UNIT III

Breeding for quality improvement in Sorghum and pearl millet; Quality protein maize – Concept and breeding strategies – Breeding for quality improvement in forage crops - Genetic resource management for sustaining nutritive quality in crops.

UNIT IV

Breeding for quality in pulses - Breeding for quality in groundnut, sesame, sunflower and minor oilseeds – Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality improvement in cotton.

UNIT V

Genetic engineering protocols for quality improvement – Achievements made - Value addition in crops; Classification and importance - Nutritional genomics and Second generation transgenics.

Practical

Grain quality evaluation in rice; Correlating ageing and quality improvement in rice - Quality analysis in millets; Estimation of antinutritional factors like tannins in different varieties/hybrids; A comparison - Quality parameters evaluation in wheat; Quality parameters evaluation in pulses - Quality parameters evaluation in oilseeds; Value addition in crop plants ; Post harvest processing of major field crops; Quality improvement in crops through tissue culture techniques; Evaluating the available populations like RIL, NIL etc. for quality improvement using MAS procedures.

Suggested Readings

- Chahal GS & Ghosal SS. 2002. Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches. Narosa Publ.
- Chopra VL. 1997. Plant Breeding. Oxford & IBH.
- FAO 2001. Speciality Rices of the World - Breeding, Production and Marketing. Oxford & IBH.
- Ghosh P. 2004. Fibre Science and Technology. Tata McGraw Hill.
- Hay RK. 2006. Physiology of Crop Yield. 2nd Ed. Blackwell.
- Nigam J. 1996. Genetic Improvement of Oilseed Crops. Oxford & IBH.
- Singh BD. 1997. Plant Breeding. Kalyani.
- Singh RK, Singh UK & Khush GS. 2000. Aromatic Rices. Oxford & IBH.

GP 514 : GENE REGULATION AND EXPRESSION 2+0

Objective

To provide insight into recent advances in the phenomenon of gene regulation and mechanisms by which plants and microbes express different traits and how these are modified during different stages.

Theory

UNIT I

Introduction: Gene regulation-purpose; Process and mechanisms in prokaryotes and eukaryotes; Levels of gene controls.

UNIT II

Coordinated genetic regulation-examples- Anthocyanin and gene families and maize; Genetic and molecular basis depending on tissue specificity.

UNIT III

Gene expression-Transposons in plant gene expression, cloning-transposon tagging; Light regulated gene expression-model systems in *Arabidopsis* and maize; Paramutations and imprinting of genes and genomes.

UNIT IV

Transgene expression and gene silencing mechanisms; Regulatory genes- horizontal and vertical homology; Transformation-regulatory genes as visible markers; Reporter systems to study gene expression; Combinatorial gene control.

UNIT V

Eukaryotic transcriptional control; Translational and post-translational regulation; Signal transduction; Stress-induced gene expression; Gene traps and enhancer traps.

Suggested Readings

- Lewin B. 2008. Genes IX. John Wiley & Sons.
- Schleif R.1986. Genetics and Molecular Biology. Addison-Wesley.
- Russell PJ. 1996. Essential Genetics. Blackwell Scientific Publ.
- Brown TA. 2002. Genomes. Bios Scientific Publ.
- Tamarin RH. 1999. Principles of Genetics. Wm C Brown Publ.
- Griffiths AJF. 2000. An Introduction to Genetic Analysis. WH Freeman.
- Hexter W & Yost HT. 1976. The Science of Genetics. Prentice Hall.
- Singer M & Berg P.1991. Genes and Genomes. John Wiley & Sons.
- Hartl DL & Jones EW. 1998. Genetics Principles and Analysis. Jones & Barlett Publ.
- Micklos DA & Freyer G. 2003. DNA Science - A First Course. CPL Scientific Publ.

- Brooker RJ. 2004. Genetics Analysis and Principles. Addison-Wesley Longman.
- Watson JD. 2004. Molecular Bilology of the Gene. Pearson Edu.

GP 515 : MAINTENANCE BREEDING AND CONCEPTS OF VARIETY RELEASE AND SEED PRODUCTION 1+1

Objective

To apprise the students about the variety deterioration and steps to maintain the purity of varieties & hybrids and principles of seed production in self & cross pollinated crops.

Theory

UNIT I

Variety Development and Maintenance; Definition- variety, cultivar,extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, hybrid,and population; Variety testing, release and notification systems in India and abroad.

UNIT II

DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding.

UNIT III

Factors responsible for genetic deterioration of varieties - safeguards during seed production; Maintenance of varieties in self and cross-pollination crops- isolation distance; Principles of seed production; Methods of nucleus and breeder seed production.

UNIT IV

Generation system of seed multiplication -nucleus, breeders, foundation, certified, - Quality seed production technology of self and cross-pollinated crop varieties viz. cereals & millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton, jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).; Seed certification procedures; Seed laws and plant variety protection regulations in India and international systems.

Practical

Identification of suitable areas/locations for seed production; Ear-to-row method and nucleus seed production - Main characteristics of released and notified varieties, hybrids and parental lines; Identification of important weeds/objectionable weeds; Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties in different crops; Hybrid seed production technology of important crops.

Suggested Readings

- Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH.
- Chhabra AK. 2006. Practical Manual of Floral Biology of Crop Plants. Department of Plant Breeding. CCS HAU Hisar.
- Kelly AF. 1988. Seed Production of Agricultural Crops. Longman.
- McDonald MB Jr & Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall.
- Musil AF. 1967. Identification of Crop and Weed Seeds. Handbook No. 219, USDA, Washington, DC.
- Poehlman JM & Borthakur D. 1969. Breeding Asian Field Crops. Oxford & IBH.
- Singh BD. 2005. Plant Breeding: Principles and Methods. Kalyani.
- Thompson JR. 1979. An Introduction to Seed Technology. Leonard Hill.
- Tunwar NS & Singh SV. 1985. Handbook of Cultivars. ICAR.

GP 516 : GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE 2+1

Objective

To provide information about collection, germplasm exchange, quarantine, maintenance and use of plant genetic resources including genetically modified plants.

Theory

UNIT I

History and importance of germplasm exploration; Distribution and extent of prevalent genetic diversity; Phyto-geographical regions/ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora.

UNIT II

Concept of population and gene pool; Variations in population and their classification; Gene frequencies in populations, rare and common alleles; Gene pool sampling in self and cross pollinated and vegetatively propagated species; Non-selective, random and selective sampling strategies; Strategies and logistics of plant exploration and collection; Coarse and fine grid surveys; Practical problems in plant exploration; Use of *in vitro* methods in germplasm collection.

UNIT III

Ethnobotanical aspects of PGR; Crop botany, farming systems, collecting wild relatives of crop plants; Collection and preservation of specimens; Importance and use of herbaria and preparation of herbarium specimens.

UNIT IV

Post-exploration handling of germplasm collections; Present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum, sesame, *Brassica*, okra, eggplant, cotton, mango etc; approaches for collection including indigenous knowledge.

UNIT V

History, principles, objectives and importance of plant introduction; Pre- requisites, conventions, national and international legislations and policies on germplasm collection and exchange; Documentation and information management; Plant quarantine- introduction, history, principles, Objectives and relevance; Regulations and plant quarantine set up in India; Pest risk analysis, pest and pathogen information database; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses, phytoplasma etc.).

UNIT VI

Detection and identification of pests including use of recent techniques like ELISA, PCR etc., Symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities; Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust.

UNIT VII

Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

Practical

Plant exploration and collection; Techniques of coarse and fine grid surveys; Identification of wild relatives of crop plants- Example of collection, cataloguing and preservation of specimens; Sampling techniques of plant materials; Visiting ports, airports to study the quarantine regulations; Techniques for the detection of insects, mites, nematodes, bacteria, weeds, pathogens and viruses on seed and planting materials and salvaging; Use of visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques(controlled green houses/growth chambers, etc); Detection of GMOs and GEPs; Study of post-entry quarantine operation, seed treatment and other prophylactic treatments.

Suggested Readings

- Briggs D. 1997. Plant Variation and Evolution. Science Publ.
- Cronquist AJ. 1981. An Integrated System of Classification of Flowering Plants. Columbia Univ. Press.
- Dhillon BS, Varaprasad KS, Kalyani S, Singh M, Archak S, Srivastava U & Sharma GD. 2001. Germplasm Conservation A Compendium of Achievements. NBPGR, New Delhi.
- di Castri F & Younes T. 1996. Biodiversity Science and Development: Towards New Partnership. CABI & International Union for Biol. Sci. France.

- Gurcharan Singh. 2004. Plant Systematics: An Integrated Approach. Science Publ.
- Lawrence GMH. (Ed.). 1951. Taxonomy of Vascular Plants. London.
- Paroda RS & Arora RK. 1991. Plant Genetic Resources Conservation and Management Concepts and Approaches. IPGRI Regional office for South and South Asia, New Delhi.
- Pearson LC. 1995. The Diversity and Evolution of Plants. CRC Press.
- Singh BP. 1993. Principles and Procedures of Exchange of Plant Genetic Resources Conservation and Management. Indo-US PGR Project Management.
- Sivarajan VV. 1991. Introduction of Principles of Plant Taxonomy. Science Publ.
- Stace CA. Plant Taxonomy and Biosystematics 2nd Ed. Cambridge Univ. Press.
- Takhrajan A. 1997. Diversity and Classification of Flowering Plants. Columbia Univ. Press.
- Wiersema JH. 1999. World Economic Plants: A Standard Reference. Blanca Leon.

GP 517 : DATA BASE MANAGEMENT, EVALUATION AND UTILIZATION OF PGR 2+1

Objective

To train the students in germplasm data base management using modern tools and softwares.

Theory

UNIT I

Statistical techniques in management of germplasm; Core identification, estimation of sample size during plant explorations, impact of sampling on population structure, sequential sampling for viability estimation; Introduction of binomial, normal and negative cumulative normal, use of Probit scales, viability equations and numograms; Estimation of sample size for storage and viability testing.

UNIT II

Germplasm documentation; Basics of computer and operating systems; Database management system, use of statistical softwares, pictorial and graphical representation of data; introduction to communication network.

UNIT III

Germplasm management system- global scenario; Genetic variation in crop plants and management of germplasm collection, limitations in use of germplasm collections; necessity of germplasm evaluation; Predictive methods for identification of useful germplasm; Characterization of germplasm and evaluation procedures including specific traits; Gene markers and their use in PGR management.

UNIT IV

Management and utilization of germplasm collections; Concept of core collection, molecular markers and their use in characterization; Evaluation and utilization of genetic resources; Pre-breeding/ genetic enhancement, utilizing wild species for crop improvement; Harmonizing agro- biodiversity and agricultural development crop diversification- participatory plant breeding.

Practical

Basics of computer and operating systems; Identification of useful germplasm, evaluation of crop germplasm; Statistical techniques in management of germplasm- estimation of sample size for storage and viability testing; Evaluation procedure and experimental protocols (designs and their analysis), Assessment of genetic diversity; Techniques of Characterization of germplasm; Molecular markers and their use in characterization.

Suggested Readings

- Painting KA, Perry MC, Denning RA & Ayad WG. 1993. Guide Book for Genetic Resources Documentation. IPGRI, Rome, Italy.
- Puzone L & Th. Hazekamp 1996. Characterization and Documentation of Genetic Resources Utilizing Multimedia Database. NBPGR, New Delhi.
- Rana RS, Sapra RL, Agrawal RC & Gambhir R. 1991. Plant Genetic Resources, Documentation and Information Management. NBPGR, New Delhi.

GP 518 : GENETIC CONTROL OF PLANT REPRODUCTION 2+0

Theory

Pollination mechanism and fertilization process and its analysis: Genetics and molecular biology of male and female gametes. Anther and ovule development. Pre- and post-fertilization barriers in wide crosses - principles and techniques to overcome fertility barriers; In vivo and in vitro fertilization mechanisms and its applications for crop improvement; Male sterility - types and mechanisms - methods of inducing male sterility in crop plants. Anther specific genes and their utility in developing male sterility. Pollination mechanisms and their evolution. Gene-flow studies in relation to transgenics. Self-incompatibility - cellular, genetic and molecular basis male genetophytic selection and its application. S gene - structure and function (case studies: tomato, Brassica, tobacco). Somatic hybridization in crop plants. Apomixis - mechanism forms and applications. Limitations, progress and prospects of transfer of apomictic trait to crop plants. Haploid parthenogenesis - induction, detection and uses.

Practical

Floral features (syndromes) in relation to mode of pollination. *In vitro* pollination. Pollen preservations and viability test. Test for stigma receptivity. Anther, ovule and ovary culture techniques. Pollen germination techniques - in vitro & in vivo study of fertility barrier in wide hybridization and demonstration (wheat, peas, Brassica, cotton). Dissection of different stages of embryo development in monocots and dicots. Embryo rescue technique.

Suggested Readings

- Kual, M.L.H, 1988. Male sterility in Higher Plants. Springer-Verlag, Berlin.
- Nettan Court D. de. 1977. Incompatability in Angiospenns. Springer - Verlag, Berlin.
- Raghavan, V. 1997. Molecular Embryology of Flowering Plants. Cambridge University Press, U.K.
- Richards A.J. 1997. Plant Breeding Systems (2nd Edition). Chapman & Hall, London.
- Shivanna, K.R. and Sawhney, V.K. 1977. Pollen Biotechnology in Crop Production and Crop Improvement. Cambridge Univ Press. U.K.
- Wyatt, R. 1992. Ecology and Evolution of Plant Reproduction. Chapman & Hall, London.

GP 519 : BREEDING OF VEGETABLE CROPS 2+1

Objective

To educate principles and practices adopted for breeding of vegetable crops.

Theory

Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, molecular marker, genomics, marker assisted breeding and QTLs, biotechnology and their use in breeding in vegetable crops-Issue of patenting, PPVFR act.

UNIT I

Potato and tomato

UNIT II

Eggplant, hot pepper, sweet pepper and okra

UNIT III

Peas and beans, amaranth, chenopods and lettuce

UNIT IV

Gourds, melons, pumpkins and squashes

UNIT V

Cabbage, cauliflower, carrot, beetroot, radish, sweet potato and tapioca

Practical

Selection of desirable plants from breeding population observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations; induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops; hybrid seed production of vegetable crops in bulk. screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops, demonstration of sib-mating and mixed population; molecular marker techniques to identify useful traits in the vegetable crops

and special breeding techniques. Visit to breeding blocks.

Suggested Readings

- Allard RW. 1999. Principles of Plant Breeding. John Wiley & Sons.
- Basset MJ. (Ed.). 1986. Breeding Vegetable Crops. AVI Publ.
- Dhillon BS, Tyagi RK, Saxena S. & Randhawa GJ. 2005. Plant Genetic Resources: Horticultural Crops. Narosa Publ. House.
- Fageria MS, Arya PS & Choudhary AK. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani.
- Gardner EJ. 1975. Principles of Genetics. John Wiley & Sons.
- Hayes HK, Immer FR & Smith DC. 1955. Methods of Plant Breeding. McGraw-Hill.
- Hayward MD, Bosemark NO & Romagosa I. (Eds.). 1993. Plant Breeding-Principles and Prospects. Chapman & Hall.
- Kalloo G. 1988. Vegetable Breeding. Vols. I-III. CRC Press.
- Kalloo G. 1998. Vegetable Breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
- Kumar JC & Dhaliwal MS. 1990. Techniques of Developing Hybrids in Vegetable Crops. Agro Botanical Publ.
- Paroda RS & Kalloo G. (Eds.). 1995. Vegetable Research with Special Reference to Hybrid Technology in Asia-Pacific Region. FAO.
- Peter KV & Pradeepkumar T. 2008. Genetics and Breeding of Vegetables. Revised, ICAR.
- Rai N & Rai M. 2006. Heterosis Breeding in Vegetable Crops. New India Publ. Agency.
- Ram HH. 1998. Vegetable Breeding: Principles and Practices. Kalyani.
- Simmonds NW. 1978. Principles of Crop Improvement. Longman.
- Singh BD. 1983. Plant Breeding. Kalyani.
- Singh PK, Dasgupta SK & Tripathi SK. 2004. Hybrid Vegetable Development. International Book Distributing Co.
- Swarup V. 1976. Breeding Procedure for Cross-pollinated Vegetable Crops. ICAR.

GP 601 : PLANT GENETIC RESOURCES AND PRE-BREEDING 2+0

Objective

To provide information about collection, evaluation, documentation, maintenance and use of plant genetic resources for crop improvement.

Theory

UNIT I

Historical perspectives and need for PGR conservation; Importance of plant genetic resources; Taxonomical classification of cultivated plants; Gene pool: primary, secondary and tertiary; Centres of origin and global pattern of diversity; Basic genetic resources and transgenes.

UNIT II

Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloging of PGR; Plant quarantine and phytosanitary certification; Germplasm introduction and exchange; Principles of *in vitro* and cryopreservation.

UNIT III

Germplasm conservation- *in situ, ex situ*, and on-farm; short, medium and long term conservation strategies for conservation of orthodox seed and vegetatively propagated crops; Registration of plant genetic resources.

UNIT IV

PGR data base management; Multivariate and clustering analysis, descriptors; National and international protocols for PGR management; PGR for food and agriculture (PGRFA); PGR access and benefit sharing; Role of CGIAR system in the germplasm exchange; PBR, Farmers rights and privileges; Seed Act, *sui generis* system; Geographical indicators, Intellectual property; Patents, copyrights, trademarks and trade secrets.

UNIT V

Journey from wild to domestication; Genetic enhancement- need for genetic enhancement; Genetic enhancement in pre Mendelian era and 21st century; Genetic enhancement and plant breeding; Reasons for failure in genetic enhancement; Sources of genes/ traits- novel genes for quality.

UNIT VI

Distant Hybridization: Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer tools and techniques into cultivated species; Validation of transferred genes and their expression.

UNIT VII

Post-genomic tools for genetic enhancement of germplasm; Prebreeding through chromosome manipulation; Application of biotechnology for Genetic enhancement- Achievements.

UNIT VIII

Utilization of genetic resources, concept of core and mini-core collections, genetic enchancement/Prebreeding for crop improvement including hybrid development.

Suggested Readings

- Frankel OH & Bennett E. 1970. Genetic Resources in Plants – their Exploration and Conservation. Blackwell.
- Gautam PL, Dass BS, Srivastava U & Duhoon SS. 1998. Plant Germplasm Collecting: Principles and Procedures. NBPGR, New Delhi.
- Painting KA, Perry MC, Denning RA & Ayad WG. 1993. Guide Book for Genetic Resources Documentation. IPGRI, Rome, Italy.
- Paroda RS & Arora RK. 1991. Plant Genetic Resources, Conservation and Management. Concepts and Approaches. IPGRI Regional office for South and South Asia, New Delhi.
- Puzone L & Hazekamp TH. 1996. Characterization and Documentation of Genetic Resources Utilizing Multimedia Database. NBPGR, New Delhi.
- Rana RS, Sapra RL, Agrawal RC & Gambhir R. 1991. Plant Genetic Resources, Documentation and Information Management. NBPGR, New Delhi.
- Singh RJ & Jauhar PP. 2005. Genetic Resources, Chromosomal Engineering and Crop Improvement. Vol. I. Grain Legumes, Vol. II. Cereals. CRC Press, Taylor & Francis Group, USA.

GP 602 : ADVANCED BIOMETRICAL AND QUANTITATIVE GENETICS 2+1

Objective

To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

UNIT I

Basic principles of Biometrical Genetics; Selection of parents; Advanced biometrical models for combining ability analysis; Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes; Designs and Systems; Selection of stable genotypes.

UNIT II

Models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Principal Component Analysis.

UNIT III

Additive and multiplicative model - Shifted multiplicative model; Analysis and selection of genotypes; Methods and steps to select the best model - Biplots and mapping genotypes.

UNIT IV

Genetic architecture of quantitative traits; Conventional analyses to detect gene actions - Partitioning of phenotypic/genotypic variance - Construction of saturated linkage maps, concept of framework map development; QTL mapping- Strategies for QTL mapping - desired populations, statistical methods; Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on markers - simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods.

Practical

Working out efficiency of selection methods in different populations and interpretation - Biparental mating – use of softwares in analysis and result interpretation - Triallel analysis– use of softwares in analysis and result interpretation - Quadriallel analysis – use of softwares in analysis and result interpretation - Triple Test Cross (TTC) – use of softwares in analysis and result interpretation - Advanced biometrical models for combining ability analysis - Selection of stable genotypes using stability analysis; Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes. Construction of linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies.

Suggested Readings

- Bos I & P Caligari. 1995. Selection Methods in Plant Breeding. Chapman & Hall.
- Falconer DS & Mackay J. 1996. Introduction to Quantitative Genetics. Longman.
- Mather K & Jinks L. 1983. Introduction to Biometrical Genetics. Chapman & Hall.
- Nadarajan N & Gunasekaran M. 2005. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani.
- Singh P & Narayanan SS. 1993. Biometrical Techniques in Plant Breeding. Kalyani.
- Singh RK & Choudhary BD. 1987. Biometrical Methods in Quantitative Genetics. Kalyani.
- Weir DS. 1990. Genetic Data Analysis. Methods for Discrete Population Genetic Data. Sinauer Associates.
- Wricke G & Weber WE. 1986. Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.

GP 603 : GENOMICS IN PLANT BREEDING 2+1

Objective

To impart practical skills in advanced molecular techniques in genome mapping structural/functional genomics and development of transgenic crops.

Theory

UNIT I

Introduction to the plant genome- Plant nuclear genomes and their molecular description - The chloroplast and the mitochondrial genomes in plants - Genome size and complexity.

UNIT II

Establishment of plant genome mapping projects - Genome mapping and use of molecular markers in plant breeding; Strategies for mapping genes of agronomic traits in plants- Approaches for mapping quantitative trait loci; Map based cloning of plant genes.

UNIT III

Regulation of Plant gene expression - Functional genomics - Expression Analysis using Microarrays – Transposon tagging and Insertional mutagenesis- methods and significance- Diversity Array Technology.

UNIT IV

Genome sequencing in plants–Principles and Techniques; Applications of sequence information in plant genome analyses; Comparative genomics– Genome Comparison Techniques- Classical and advanced approaches.

UNIT V

Detection of Single Nucleotide Polymorphism; TILLING and Eco- TILLING; Role of transcriptomics, proteomics and metabolomics in linking genome and phenome; Importance of understanding the phenotypes for exploiting the outcome of genomic technologies- Knock out mutant studies and high throughput phenotyping.

UNIT VI

Concept of database development, management and bioinformatics; Plant genome projects and application of bioinformatics tools in structural and functional genomics.

Practical

Chromosome analysis in major field crops - Fluorescence *in situ* hybridization - Comparative genomic hybridization – Comparative analysis of plant genomes using molecular markers – Genetic map construction using molecular markers – Mapping major genes using molecular markers
– QTL mapping in plants – Comparison across mapping populations – Understanding the need genetic algorithms in QTL mapping – Plant Genome Databases – Computational tools to explore plant genome databases – Comparative genomics – Comparison of genome sequences using tools of bioinformatics- Advanced genomic technologies: TILLING and Eco-TILLING – DNA Array Technology – Linking genome sequences to phenotypes: Tools of transcriptomics, proteomics and metabolomics.

Suggested Readings

- Baxevanis AD & Ouellette BFF. 2001. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Wiley Interscience.
- Brown TA. 2002. Genomes. Wiley-LISS.
- Caetano-Anolles G & Gresshoff PM. 1998. DNA Markers: Protocols, Applications and Overviews. Wiley-VCH.
- Cantor CR & Smith CL (2004). Genomics. Wiley, New York.
- Galas DJ & McCormack SJ. 2002. Genomic Technologies: Present and Future. Calster Academic Press.
- Jordan BR. 2001. DNA Microarrays: Gene Expression Applications. Springer-Verlag.
- Liu BH. 1997. Statistical Genomics: Linkage, Mapping and QTL Analysis. CRS Press.
- Lynch M & Walsh B. 1998. Genetics and Analysis of Quantitative Traits. Sinauer Associates.
- Mount DW. 2001. Bioinformatics. Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
- Palzkill T. 2002. Proteomics. Kluwer.
- Paterson AH. 1996. Genome Mapping in Plants. Academic Press.
- Pennington SR & Dunn MJ. 2002. Proteomics: From Protein Sequence to Function. Viva Books.
- Rampal JB. 2001. DNA Arrays: Methods and Protocols. Humana Press.

GP 604 : MOLECULAR AND CHROMOSOMAL MANIPULATIONS FOR CROP BREEDING 2+0

Objective

This course focuses on the advanced techniques in analyzing chromosome structure and manipulations for genome analysis in crop species.

Theory

UNIT I

Organization and structure of genome – Genome size – Organization of organellar genomes – Nuclear DNA organization – Nuclear and Cytoplasmic genome interactions and signal transduction; Transcriptional and Translational changes, Inheritance and expression of organellar DNA; Variation in DNA content – C value paradox; Sequence complexity – Introns and Exons – Repetitive sequences – Role of repetitive sequence.

UNIT II

Karyotyping – Chromosome banding and chromosome painting; Tracking introgressions using FISH, GISH, loclalization and mapping of genes/genomic segments; Distant hybridization - Role of polyploids in crop evolution and breeding - auto and allopolyploids.

UNIT III

Applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchange- genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges-use in producing inbreds, transfer of genes- linked marker methods; Duplication - production and use; Inversions and location of genes; B/A chromosome translocations and gene location.

UNIT IV

Trisomics- types, production, breeding behavior and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomics- methods of production, breeding behavior and location of genes; Intervarietal substitutions-allelic and non-allelic interactions; Telocentric method of mapping.

UNIT V

Barriers to interspecific and intergeneric hybridization- Behaviour of interspecific and intergeneric crosses; Totipotency of cells – Morphogenesis: *in vivo* and *in vitro* – Meristem culture – anther and pollen culture – ovule, ovary, embryo and endosperm culture – protoplast isolation and culture – protoplast fusion, Different pathways of *in vitro* morphogenesis – organogenesis and somatic embryogenesis; *in vitro* mutant/somaclone selection for biotic and abiotic stresses.

Suggested Readings

- Clark MS & Wall WJ. 1996. Chromosomes: The Complex Code. Chapman & Hall.
- Conger BV. (Ed.). 1981. Cloning Agricultural Plants via in vitro Techniques. CRC Press.
- Constabel F & Vasil IK. (Eds.). 1988. Cell Culture and Somatic Cell Genetics of Plants. Vol. V. Cell Culture and Phytochemicals in Plant Cell Cultures. Academic Press.
- Lal R & Lal S. (Eds.). 1990. Crop Improvement Utilizing Biotechnology.CRC Press.
- Mantel SH & Smith H. 1983. Plant Biotechnology. Cambridge University Press.
- Sen SK & Giles KL. (Eds.). 1983. Plant Cell Culture in Crop Improvement. Plenum Press.

GP 605 : ADVANCES IN PLANT BREEDING SYSTEMS 2+0

Objective

To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory

UNIT I

Facts about plant breeding before the discovery of Mendelism; Evolutionary concepts of genetics and plant breeding - Flower development and its importance; genes governing the whorls formation and various models proposed; Mating systems and their exploitation in crop breeding; Types of pollination, mechanisms promoting cross pollination.

UNIT II

Selection in cross fertilizing crops – Polycross and topcross selections, Mass and recurrent selection methods and their modifications - Mass selection: grided mass selection, ear to row selection, modified ear to row selection; Convergent selection, divergent selection; Recurrent selection: Simple recurrent selection and its modifications (restricted phenotypic selection, selfed progeny selection and full sib recurrent selection) - Recurrent selection for general combining ability (GCA) – Concepts and utilization - Recurrent selection for specific combining ability (SCA) – usefulness in hybrid breeding programmes - Reciprocal recurrent selection (Half sib reciprocal recurrent selection, Half sib reciprocal recurrent selection with inbred tester and Full sib reciprocal recurrent selection); Selection in clonally propagated crops – Assumptions and realities.

UNIT VI

Genetic engineering technologies to create male sterility; Prospects and problems - Use of self- incompatability and sterility in plant breeding – case studies; - Fertility restoration in male sterile lines and restorer diversification programmes - Conversion of agronomically ideal genotypes into male steriles – Concepts and breeding strategies; Case studies - Generating new cytonuclear interaction system for diversification of male steriles - Stability of male sterile lines – Environmental influence on sterility– Environmentally Induced Genic Male Sterility (EGMS) - Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding - Temperature sensitive genetic male sterility and its use heterosis breeding - Apomixis and its use in heterosis breeding - Incongruity - Factors influencing incongruity - Methods to overcome incongruity mechanisms.

Suggested Readings

- Agarwal RL. 1996. Fundamentals of Plant Breeding and Hybrid Seed Production. Oxford & IBH.
- Allard RW. 1966. Principles of Plant Breeding. John Wiley & Sons.
- Briggs FN & Knowles PF. 1967. Introduction to Plant Breeding. Reinhold.
- Fehr WR. 1987. Principles of Cultivar Development: Theory and Technique. Vol I. Macmillan.
- Hayes HK, Immer FR & Smith DC. 1955. Methods of Plant Breeding. McGraw-Hill.
- Mandal AK, Ganguli PK & Banerji SP. 1995. Advances in Plant Breeding. Vol. I, II. CBS.
- Richards AJ. 1986. Plant Breeding Systems. George Allen & Unwin.
- Sharma JR. 1994. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
- Simmonds NW. 1979. Principles of Crop Improvement. Longman.
- Singh BD. 1997. Plant Breeding: Principles and Methods. 5th Ed., Kalyani.
- Singh P. 1996. Essentials of Plant Breeding. Kalyani.
- Welsh JR. 1981. Fundamentals of Plant Genetic and Breeding. John Wiley.
- Williams W. 1964. Genetical Principles and Plant Breeding. Blackwell.

GP 606 : CROP EVOLUTION 2+0

Objective

To impart knowledge on crop evolutionary aspects and manipulation at ploidy level for crop improvement.

Theory

UNIT I

Origin and evolution of species; Centres of diversity/origin, diffused centres; Time and place of domestication; Patterns of evolution and domestication-examples and Case studies.

UNIT II

Domestication and uniformity – Characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift - Consequences.

UNIT III

Speciation and domestication – The process of speciation – Reproductive isolation barriers – Genetic differentiation during speciation – Hybridization - speciation and extinction.

UNIT IV

Exploitation of natural variation – Early attempts to increase variation – Distant hybridization and introgression- Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques; Validation of transferred genes and their expression; Controlled introgressions.

UNIT V

Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution – Multifactorial genome – Intragenomic interaction – Intergenomic interaction – Genome introgression.

UNIT VI

Methods to study crop evolution - Contemporary Methods – Based on morphological features – Cytogenetic analysis – Allozyme variations and crop evolution – DNA markers, genome analysis and comparative genomics.

UNIT VII

Evolutionary significance of polyploidy, Evolution of crop plants through ploidy manipulations; polyploids: methods, use of autopolyploids; haploidy-method of production and use; allopolyploids- synthesis of new crops; - Case studies – Cereals – Pulses – Oilseeds – vegetables, Fibre crops - Plantation crops – Forage crops – Tuber crops – Medicinal Plants.

Suggested Readings

- Hancock JF. 2004. Plant Evolution and the Origin of Crop Species. 2nd Ed. CABI.
- Ladizinsky G. 1999. Evolution and Domestication. Springer.
- Miller AJ. 2007. Crop Plants: Evolution. John Wiley & Sons.
- Smartt J & Simmonds NW. 1995. Evolution of Crop Plants. Blackwell.

GP 607 : BREEDING DESIGNER CROPS 2+1

Objective

To impart theoretical knowledge and practical know-how towards physiological efficiency, nutritional enhancement, biofortification and industrial/pharma applications in plant breeding.

Theory

UNIT I

Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins, vaccines, gums, starch and fats.

UNIT II

Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement.

UNIT III

Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of suboptimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.

UNIT IV

Breeding for special traits viz. oil, protein, vitamins, amino acids etc.; Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories in vaccines, modified sugars, gums and starch through biopharming

UNIT V

Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management

Practical

Demonstration of plant responses to stresses through recent techniques; Water use efficiency, transpiration efficiency, screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation, heat/drought/salt shock proteins.

Suggested Readings

- Balint A. 1984. Physiological Genetics of Agricultural Crops. AK Ademiaikiado.
- Hay RK. 2006. Physiology of Crop Yield. 2nd Ed. Blackwell.
- Pessarakli M. 1995. Handbook of Plant and Crop Physiology. Marcel Dekker.
- Taiz L & Zeiger E. 2006. Plant Physiology. 4th Ed. Sinauer Associates.

GP 608 : ADVANCES IN BREEDING OF MAJOR FIELD CROPS 3+0

Objective

To provide insight into recent advances in improvement of cereals, millets and non cereal crops using conventional and modern biotechnological approaches.

Theory

UNIT I

History, description, classification, origin and phylogenetic relationship, genome status in cultivated and alien species of major cereals, millets and non cereal crops like Rice, Wheat, Maize, Pearlmillet, Sorghum , Pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc.

UNIT II

Breeding objectives in rice, wheat, maize, pearlmillet, sorghum, pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Genetic resources and their utilization; Genetics of quantitative and qualitative traits.

UNIT III

Breeding for value addition and resistance to abiotic and biotic stresses.

UNIT IV

Conventional (line breeding, population improvement, hybrids) and other approaches (DH Populations, Marker Assisted Breeding, Development of new male sterility systems), transgenics.

UNIT V

National and International accomplishments in genetic improvement of major field crops and their seed production.

Suggested Readings

- Chopra VL. 2001. Breeding Field Crops - Theory and Practice. Oxford & IBH.
- Davis DD.1978. Hybrid Cotton Specific Problems and Potentials. Adv. Agron.30:129-157.
- Heyne EG. 1987. Wheat and Wheat Improvement. 2nd Ed. ASA, CSSA, SSSA Inc Publ.
- Khairwal, IS, Rai KN & Harinaryanan H. (Eds.). 1999. Pearl Millet Breeding. Oxford & IBH.
- Khairwal I, Ram C & Chhabra AK. 1990. Pearl Millet Seed Production and Technology. Manohar Publ.
- Nagarajan S, Singh G & Tyagi BS. 1998. Wheat Research Needs Beyond 2000 AD. Narosa.
- Nanda JS. 2000. Rice Breeding and Genetics - Research Priorities and Challenges. Oxford & IBH.
- Rao VS, Singh G & Misra SC. 2004. Wheat: Technologies for Warmer Areas. Annamaya Publ.
- Reynolds MP, Rajaram S, McNab A. 1996. Increasing Yield Potential in Wheat: Breaking the Barriers. Proc. Workshop held in Ciudad, Obregon, Sonora, Mexico.
- Seth BL, Sikka SM, Dastur RH, Maheshwari P, Rangaswamy NS & Josi AB. 1960. Cotton in India – A Monograph. Vol. I. ICAR.
- Singh BD. 2006. Plant Breeding - Principles and Methods. Kalyani.
- Singh P & Singh S. 1998. Heterosis Breeding in Cotton. Kalyani.
- Singh P. 1998. Cotton Breeding. Kalyani.
- Singh S & Singh P. 2006. Trends in Wheat Breeding. Kalyani Publ.

GP 609 : MICROBIAL GENETICS 2+1

Objective

The objective of this course is to apprise the students of molecular processes at DNA and RNA level in different microorganisms, especially bacteria and viruses.

Theory

UNIT I

Nature of bacterial variation; Molecular aspects of mutation; Episomes and plasmids; Gene mapping in bacteria; Life cycle of bacteriophages; Genetic fine analysis of rII locus; Circular genetic map of phage T4; Transposable elements; Gene manipulation; Biochemical genetics of *Neurospora and Sacharomyces* ; One gene - one enzyme hypothesis.

UNIT II

Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Molecular chaperones and gene expression; Genetic basis of apoptosis.

UNIT III

Transgenic bacteria and bioethics; genetic basis of nodulation, nitrogen fixation and competition by rhizobia, genetic regulation of nitrogen fixation and quorum sensing in rhizobia; genetics of mitochondria and chloroplasts.

Practical

Preparation and sterilization of liquid and agar bacterial nutrient media; Assessment of generation time in the log-phage bacterial cultures.

Handling of microorganisms for genetic experiments; Isolation of rhizobia from nodules; Gram staining of rhizobial cells; Examination of polyhydroxy butyrate (PHB) production in rhizobia; Demonstration of N_2- fixing nodules/bacterial inoculation in the legume- *Rhizobium* symbiotic system.

Induction, isolation and characterization of auxotrophic and drug resistant mutants in bacteria; determination of spontaneous and induced mutation frequencies; Discrete bacterial colony counts for the preparation of survival curves and determination of LD_{50} of a mutagen. Tn-mediated mutagenesis; Analysis and isolation of plasmid DNA; Curing of plasmids.

Suggested Readings

- Brooker RJ. 2004. Genetics Analysis and Principles. Addison-Wesley Longman.
- Brown TA. 2002. Genomes. Bios Scientific Publ.
- Griffiths AJF. 2000. An Introduction to Genetic Analysis. WH Freeman.
- Hexter W & Yost HT 1976. The Science of Genetics. Prentice Hall.
- Karp G. 2004. Cell and Molecular Biology: Concepts and Experiments. John Wiley.
- Lewin B. 2008. Genes IX. John Wiley & Sons.
- Russell PJ. 1996. Essential Genetics. Blackwell Scientific Publ.
- Russell PJ. 1996. Essential Genetics. Blackwell Scientific Publ.
- Schleif R.1986. Genetics and Molecular Biology. Addison-Wesley Publ. Co.
- Tamarin RH. 1999. Principles of Genetics. Wm C Brown Publ.
- Watson JD. 2004. Molecular Bilology of the Gene. Pearson Edu.
- Yadav AS, Vasudeva M, Kharab P & Vashishat RK. 2002. Practical Manual on Microbial and Molecular Genetics. Dept. of Genetics, CCS HAU Hisar.

GP 610 : IN SITU AND EX SITU CONSERVATION OF GERMPLASM 2+1

Objective

To impart knowledge on the methods of germplasm conservation.

Theory

UNIT I

Concept of natural reserves and natural gene banks, *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ* conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

UNIT II

Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, *perma-frost* conservation, guidelines for sending seeds to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling ,clonal repositories, genetic stability under long term storage condition.

UNIT III

In vitro storage, maintanence of *in vitro* culture under different conditions, *in vitro* bank maintanence for temporate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems , prospects of *in vitro* gene bank.

UNIT IV

Cryopreservation- procedure for handling seeds of orthodox and recalcitrants-cryoprotectants, dessication, rapid freezing, slow freezing, vitrification techniques, encapsulation/ dehydration techniques, national facilities, achievements, application of cryopreservation in agriculture, horticulture and forestry crops.Problems and prospects; challenges aheads.

Practical

In situ conservation of wild species –case studies at national and international levels- *ex situ* techniques for active and long-term conservation of collections- Preparation and handling of materials, packaging, documentation; design of cold storage modules- Conservation protocols for recalcitrant and orthodox seeds; Cytological studies for assessing genetic stability, *in vitro* cultures-embryo,cell/suspension cultures,pollen cultures, study of cryotank facility and vitrifica-tion techniques, visit to NBPGR/NBAGR -study using fruit crops and other

horticultural crops.

Suggested Readings

- Ellis RH & Roberts EH & White Head J. 1980. A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks. FAO / IBPGR Pl. Genet. Resources News 41-3-18.
- Frankel OH & Hawkes JG. 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press, Cambridge.
- Simmonds, N.W. 1979. Principles of Crop Improvement Longman.
- Westwood MN. 1986. Operation Manual for National Clonal Germplasm Repository Processed *Report*. USDA-ARS and Orgon State Univ. Oregon, USA.
- Withers LA. 1980. Tissue Culture Storage for Genetic Conservation. IBPGR Tech. Rep. IBPGR, Rome, Italy.

SEED SCIENCE AND TECHNOLOGY

SST 501 : FLORAL BIOLOGY, SEED DEVELOPMENT AND MATURATION 1+1

Objective

To refresh the basic knowledge of seed development and structures and apprise students with its relevance to production of quality seed.

Theory

UNIT I

Floral types, structure and biology in relation to pollination mechanisms; sporogenesis: microsporogenesis and megasporogenesis; gametogenesis - development of male and female gametes and their structures; effect of environmental factors on floral biology.

UNIT II

Fertilization – embryo sac structure, process, barriers to fertilization, incompatibility and male sterility, factors affecting fertilization.

UNIT III

Embryogenesis - development of typical monocot and dicot embryos; endosperm development, modification of food storage structures with reference to crop plants; different types of embryos, endosperm and cotyledons; development and their structure in representative crop plants with reference to food storage; external and internal features of monocot and dicot seed; seed coat structure and development in representative crop plants.

UNIT IV

Apomixis – identification, classification, significance and its utilization in different crops for hybrid seed production; Polyembryony - types and significance; haplontic and diplontic sterility, causes of embryo abortion, embryo rescue and synthetic seeds.

Practical

Study of floral biology of monocots and dicots; microsporogenesis and megasporogenesis; study of pollen grains - pollen morphology, pollen germination and pollen sterility; types monocot and dicot embryos; external and internal structures of monocot and dicot seeds; seed coat structure, preparation of seed albums and identification.

Suggested Readings

- Bhojwani SS & Bhatnagar SP. 1999. The Embryology of Angiosperm. Vikas Publ.
- Black M, Bewley D & Halmer P. 2006. The Encyclopedia of Seeds: Science, Technology and Uses. CABI.
- Chhabra AK. 2006. Practical Manual of Floral Biology of Crop Plants. Deptt. of Plant Breeding, CCS HAU, Hisar.
- Copeland LO & McDonald MB. 2001. Principles of Seed Science and Technology. 4th Ed. Chapman & Hall.

❖ Frankel R & Galun E. 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Springer Verlag.

SST 502 : PRINCIPLES OF SEED PRODUCTION 2+0

Objective

To introduce the basic priciples of quality seed production.

Theory

UNIT I

Introduction : Seed as basic input in agriculture; seed development in cultivated plants; seed quality concept and importance of genetic purity in seed production; types of cultivars, their maintenance and factors responsible for deterioration; seed production in self and cross pollinated crops.

UNIT II

Mode of pollination and reproduction in crop plants and their modification in relation to hybrid seed production. Principles of hybrid seed production, isolation distance, synchronization of flowering, roguing etc. male sterility and incompatibility system in hybrid seed production, role of pollinators and their management.

UNIT III

Seed multiplication ratios, seed replacement rate, demand and supply; suitable areas of seed production and storage, agronomy of seed production – agro climatic requirements and their influence on quality seed production; generation system of seed multiplication; maintenance of Nucleus seed, production of Breeder, Foundation and Certified seed– criteria involved; life span of a variety and causes for its deterioration; certification standards for self and cross pollinated and vegetatively propagated crops.

UNIT IV

Hybrid Seed - Methods of development of hybrids; use of male sterility and self-incompatibility and CHA in hybrid seed production; one, two and three line system; maintenance of parental lines of hybrids; planning and management of hybrid seed production technology of major field crops and vegetables.

UNIT V

Planning of seed production for different classes of seeds for self and cross- pollinated crops, Seed quality control system and organization, seed village concept; Seed production agencies, seed industry and custom seed production in India.

Suggested Readings

❖ Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH.
❖ Chhabra AK. 2006. Practical Manual of Floral Biology of Crop Plants. Dept. of Plant Breeding CCS HAU, Hisar.
❖ Desai BB. 2004. Seeds Handbook. Marcel Dekker.
❖ Kelly AF. 1988. Seed Production of Agricultural Crops. Longman.
❖ McDonald MB Jr & Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall.
❖ Musil AF. 1967. Identification of Crop and Weed Seeds. Handbook No. 219, USDA, Washington, DC, USA.
❖ Poehlman JM & Sleper DA. 2006. Breeding Field Crops. Blackwell.
❖ Singh BD. 2005. Plant Breeding: Principles and Methods. Kalyani.
❖ Singhal NC. 2003. Hybrid Seed Production in Field Crops. Kalyani.
❖ Thompson JR. 1979. An Introduction to Seed Technology. Leonard Hill.
❖ Tunwar NS & Singh SV. 1985. Handbook of Cultivars. CSCB, GOI.

SST 503 : SEED PRODUCTION IN FIELD CROPS 2+1

Objective

To impart a comprehensive knowledge of seed production in field crops with adequate practical training.

Theory

UNIT I

Basic principles in seed production and importance of quality seed. Floral structure, breeding and pollination mechanism in self-pollinated cereals and millets viz, wheat, barley, paddy, ragi etc.

UNIT II

Floral structure, breeding and pollination mechanism in cross-pollinated cereals and millets viz maize, sorghum, bajra etc ; methods and techniques of quality seed production incross-pollinated cereals and millets.

UNIT III

Floral structure, breeding and pollination mechanism; methods and techniques of seed production in pulses (pigeon pea, chick pea, green garm, black garm, field beans, peas etc.).

UNIT IV

Floral structure, breeding and pollination mechanism; methods and techniques of seed production in major oil seeds (groundnut, castor, sunflower, safflower, rape and mustard, linseed, sesame etc.).

UNIT V

Floral structure, breeding and pollination mechanism; methods and techniques of seed production in commercial fibers (cotton, jute, mesta etc) and vegetatively propagated crops like sugar cane, potato etc.

Practical

Planning of Seed Production, requirements for different classes of seeds in field crops - unit area and rate; Seed production in cross pollinated crops with special reference to land, isolation, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony; supplementary pollination, pollen storage, hand emasculation and pollination in Cotton, detasseling in Corn, identification of rogues and pollen shedders; Pollen collection, storage, viability and stigma receptivity; gametocide application and visits to seed production plots etc.

Suggested Readings

- Kelly AF. 1988. Seed Production of Agricultural Crops. John Wiley.
- McDonald MB Jr & Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall.
- Singhal NC. 2003. Hybrid Seed Production in Field Crops. Kalyani.

SST 504 : SEED PRODUCTION IN VEGETABLES 2+1

Objective

To impart a comprehensive knowledge of seed production in vegetable crops with adequate practical training

Theory

UNIT I

Introduction; modes of propagation in vegetables. Seed morphology and development in vegetable seeds. Floral biology of these plant species; classification of vegetable crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops.

UNIT II

Classification based on growth cycle and pollination behavior; methods of seed production; comparison between different methods e.g. seed-to-seed vs. root-to-seed method in radish; seed multiplication ratios in vegetables; pollination mechanisms; sex types, ratios and expression and modification of flowering pattern in cucurbits; nursery raising and transplanting stage.

UNIT III

Seed production technology of vegetables viz. solanaceous, cucurbitaceous, leguminous, malvaceous, cole crops, leafy vegetables, root, tuber and bulb crops and spices; harvesting/picking stage and seed extraction in fruit vegetables; clonal propagation and multiplication in tuber crops e.g. Potato, sweet potato, colocasia, tapioca; seed-plot technique in potato tuber seed production; hybrid seed production technology of vegetable crops, TPS

(true potato seed) and its production technique; hybrids in vegetables; maintenance of parental lines; use of male sterility and self incompatibility in hybrid seed production, environmental factors related to flowering/bolting in vegetable crops.

UNIT IV

Share of vegetable seeds in seed industry; importance and present status of vegetable industry; intellectual property rights and its implications, impact of PVP on growth of seed industry.

Practical

Selection of suitable areas/locations for high quality seed/planting material production; study of floral biology of vegetables, determination of planting ratios for hybrid seed production vegetables; use and maintenance of monoecious line in hybrid seed production of cucumber; exercises on emasculation and pollination; seed extraction methods and their effect on quality of vegetables; seed production technology of varieties and hybrids in vegetables.

Suggested Readings

- Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH.
- Desai BB, Katecha, PM & Salunke DK.1997. Seed Hand Book: Biology, Production, Processing and Storage. Marcel Dekker.
- Desai BB. 2004. Seeds Handbook. Marcel Dekker.
- George RAT. 1980. Vegetable Seed Technology. A Technical Guide to Vegetable Seed Production, Processing, Storage and Quality Control. FAO, Rome.
- Hartman HT & Kester DE. 2000. Plant Propagation: Principles and Practices. Prentice Hall.
- Kelly AF & George RAT. (Eds.).1998. Encyclopedia of Seed Production of World Crops. John Wiley & Sons.
- McDonald MB Jr & Copeland LO. 1997. Seed Production of Crops: Principles and Practices. Chapman & Hall.
- Salunkhe DK, Desai BB & Bhat RN. 1987. Vegetable and Flower Seed Production. Agricole Publ. Academy.
- Singh SP. 2001. Seed Production of Commercial Vegetables. Agrotech. Singhal NC. 2003. Hybrid Seed Production in Field Crops. Kalyani.

SST 505 : SEED PRODUCTION IN FLOWERS AND MEDICINAL, FRUITS AND PLANTATION CROPS 2+1

Objective

To impart comprehensive knowledge of seed production in horticultural crops with adequate practical training

Theory

UNIT I

Introduction: modes of propagation in flower and Meditional crops. classification of medicinal crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops.

UNIT II

Flowers and Medicinal Plants; classification based on growth cycle, reproduction and pollination behavior; nursery requirement, planning and management; technology for quality seed production in important flower species i.e. marigolds, petunias, dahlia, roses, gladiolus, tulips, chrysanthemum etc; development of hybrids and their seed production technology flower plants.

UNIT III

IPR issues with special reference to floral and plantation crops.

Practical

Selection of suitable areas/locations for high quality seed/planting material production; study of floral biology of flowers, fruits, medicinal and plantation crops; determination of planting ratios for hybrid seed production in flowers; exercises on emasculation and pollination; seed extraction methods and their effect on quality of fruit; seed production technology of varieties and hybrids; seed collection and extraction in fruit and plantation crops.

Suggested Readings

- Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH.
- Desai BB, Katecha, PM & Salunke DK.1997. Seed Hand Book: Biology, Production, Processing and Storage. Marcel Dekker.
- Desai BB. 2004. Seeds Handbook. Marcel Dekker.
- Doijode SD. 2001. Seed Storage of Horticultural Crops. CBS.
- George RAT. 1980. Vegetable Seed Technology. A Technical Guide to Vegetable Seed Production, Processing, Storage and Quality Control. FAO, Rome.
- Hartman HT & Kester DE. 2000. Plant Propagation: Principles and Practices. Prentice Hall.
- ICAR. Hand Book of Horticulture. ICAR Publ.
- Kelly AF & George RAT. (Eds.).1998. Encyclopedia of Seed Production of World Crops. John Wiley & Sons.
- McDonald MB Jr & Copeland LO. 1997. Seed Production of Crops: Principles and Practices. Chapman & Hall.
- Salunkhe DK, Desai BB & Bhat RN. 1987. Vegetable and Flower Seed Production. Agricole Publ. Academy.
- Singh SP. 2001. Seed Production of Commercial Vegetables.Agrotech. Singhal NC. 2003. Hybrid Seed Production in Field Crops. Kalyani.

SST 506 : SEED LEGISLATION AND CERTIFICATION 2+1

Objective

To apprise students with the legislative provisions and processes and the mechanisms of seed quality control.

Theory

UNIT I

Historical development of Seed Industry in India; Seed quality: concept and factors affecting seed quality during different stages of production, processing and handling; seed quality control- concept and objectives; Central Seed Certification Board (CSCB).

UNIT II

Regulatory mechanisms of seed quality control- organizations involved in seed quality control programmes; seed legislation and seed law enforcement as a mechanism of seed quality control; the Seed Act (1966), Seed Rules (1968), Seed (Control) Order 1983; Essential Commodities Act (1955); Plants, Fruits and Seeds Order (1989); National Seed Development Policy (1988) and EXIM Policy regarding seeds, plant materials; New Seed Bill-2004 etc. Introduction, objectives and relevance of plant quarantine, regulations and plant quarantine set up in India.

UNIT III

Seed Certification- history, concept and objectives of seed certification; seed certification agency/organization and staff requirement; legal status and phases of seed certification; formulation, revision and publication of seed certification standards; Indian Minimum Seed Certification Standards (I.M.S.C.S.)- general and specific crop standards including GM varieties, field and seed standards; planning and management of seed certification programmes- eligibility of a variety for certification, area assessment, cropping history of the seed field, multiplication system based on limited generation concept, isolation and land requirements etc.

UNIT IV

Field Inspection- principles, phases and procedures; reporting and evaluation of observations; pre and post-harvest control tests for genetic purity evaluation (grow-out tests); post harvest inspection and evaluation; seed sampling, testing, labeling, sealing and grant of certificate; types and specifications for tags and labels; maintenance and issuance of certification records and reports; certification fee and other service charges; training and liaison with seed growers. OECD seed certification schemes.

UNIT V

Introduction to WTO and IPRs; Plant Variety Protection and its significance; UPOV and its role; DUS testing- principles and applications; essential features of PPV & FR Act, 2001 and related Acts.

Practical

General procedure of seed certification ; identification of weed and other crop seeds as per specific crops; field inspection at different stages of a crop and observations recorded on contaminants and reporting of results; inspection and sampling at harvesting/threshing, processing and after processing for seed law enforcement; testing physical purity, germination and moisture; specifications for tags and labels to be used for certification purpose; grow-out tests for pre and post-harvest quality control; visits to regulatory seed testing laboratory, including plant quarantine lab and seed certification agency.

Suggested Readings

- Agarwal RL. 1997. Seed Technology. Oxford & IBH.
- Anonymous 1992. Legislation on Seeds. NSC Ltd., Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi.
- Nema NP. 1986. Principles of Seed Certification and Testing. Allied Publs.
- Tunwar NS & Singh SN. 1988. Indian Minimum Seed Certification Standards. CSCB, Ministry of Agriculture, New Delhi.

SST 507 : SEED PROCESSING AND STORAGE 2+1

Objective

To impart knowledge on the principles and techniques of seed processing for quality upgradation and of storage for maintenance of seed quality.

Theory

UNIT I

Introduction: Principles of seed processing; methods of seed drying including dehumidification and its impact on seed quality. Relative humidity and equilibrium moisture content of seed; Thumb rules of seed storage; loss of viability in important agricultural and horticultural crops, viability equations and application of nomograph.

UNIT II

Seed cleaning equipment and their functions: Preparing seed for processing; functions of scalper debearder, scarifier, huller, seed cleaner and grader. Screen cleaners, specific gravity separator, indented cylinder, velvet-spiral-disc separators, colour sorter, delinting machines; seed blending.

UNIT III

Assembly line of processing and storage, receiving, elevating and conveying equipments, plant design and layout, requirements and economic feasibility of seed processing plant.

UNIT IV

Seed treatments-methods of seed treatment, seed treating formulations and equipments, seed disinfestations, identification of treated seeds; Packaging: principles, practices and materials; bagging and labeling.

UNIT V

Seed storage: Seed drying and storage; drying methods-importance and factors affecting it, changes during storage, concepts and significance of moisture equilibrium, methods of maintaining safe seed moisture content. Methods to minimize the loss of seed vigour and viability; factors influencing storage losses. Storage methods and godown sanitation. Storage structures. Storage problems of recalcitrant seeds and their conservation.

Practical

Operation and handling of mechanical drying equipments; effect of drying temperature and duration on seed germination and storability with particular reference to oil seeds; seed extraction methods; seed processing equipments; seed treating equipments; visit to seed processing plant and commercial controlled and uncontrolled Seed Stores;. seed quality upgradation; measurement of processing efficiency; seed blending, bag closures; study of orthodox, intermediary and recalcitrant seeds; evaluating seed viability at different RH and temperature levels and packaging materials; prediction of storability by accelerated ageing

controlled deterioration tests.

Suggested Readings

- Agrawal RL. 1996. Seed Technology. Oxford Publ.
- Barton LV. 1985. Seed Preservation and Longevity. International Books and Periodicals Supply Service, New Delhi.
- Hall CW. 1966. Drying of Farms Crops. Lyall Book Depot.
- Justice OL & Bass LN. 1978. Principles and Practices of Seed Storage. Castle House Publ. Ltd.
- Mathews RK, Welch GB, Delouche JC & Dougherty GM. 1969. Drying, Processing and Storage of Corn seed in Tropical and Subtropical Regions. Proc. Am. Agric. Eng. St. Joseph, Mich. Paper No. 69-67.
- Sahay KM & Singh K K. 1991. Unit Operations in Food Engineering. Vikas Publ.
- Virdi SS & Gregg BG. 1970. Principles of Seed Processing. National Seed Corp., New Delhi.

SST 508 : SEED QUALITY TESTING 2+1

Objective

To provide a comprehensive knowledge on all aspects of seed quality evaluation and their relevance to crop performance.

Theory

UNIT I

Introduction: Structure of monocot and dicot seeds; seed quality: objectives, concept and components and their role in seed quality control; instruments, devices and tools used in seed testing. ISTA and its role in seed testing.

UNIT II

Seed Sampling: definition, objectives, seed-lot and its size; types of samples; sampling devices; procedure of seed sampling; sampling intensity; methods of preparing composite and submitted samples; sub-sampling techniques, dispatch, receipt and registration of submitted sample in the laboratory, sampling in the seed testing laboratory.

UNIT III

Physical Purity: definition, objective and procedure, weight of working samples for physical purity analysis; components of purity analysis and their definitions and criteria; pure seed definitions applicable to specific genera and families; multiple seed units; general procedure of purity analysis; calculation and reporting of results, prescribed seed purity standards; determination of huskless seeds; determination of weed seed and other seed by number per kilogram; determination of other distinguishable
varieties (ODV); determination of test weight and application of heterogeneity test.

UNIT IV

Seed moisture content: importance of moisture content; equilibrium moisture content; principles and methods of moisture estimation - types, instruments and devices used; pre-drying and grinding requirements, procedural steps in moisture estimation; calculation and reporting of results.

UNIT V

Germination: importance; definitions; requirements for germination, instrument and substrata required; principle and methods of seed germination testing; working sample and choice of method; general procedure for each type of method; duration of test; seedling evaluation; calculation and reporting of results; dormancy: definition, importance, causal mechanisms, types and methods for breaking dormancy.

UNIT VI

Viability and Vigour Testing: definition and importance of viability tests; different viability tests; quick viability test (TZ- test) - advantages, principle, preparation of seeds and solutions, procedure, evaluation and calculation of test results. Vigour testing: concept, historical development, definitions, principles and procedures of different methods used for testing vigour.

UNIT VII

Genetic purity testing : objective and criteria for genetic purity testing; types of test; laboratory, Growth Chamber and field testing based on seed , seedling and mature plant morphology; principles and procedures of chemical, biochemical and molecular tests.

UNIT VIII

Seed health Testing: field and seed standards ; designated diseases, objectionable weeds - significance of seed borne disease vis-a-vis seed quality - seed health testing and detection methods for seed borne fungi, bacteria, viruses and nematodes.

UNIT IX

Testing of GM seeds and trait purity, load of detection (LOD).

UNIT X

Preparation and dispatch of seed testing reports; storage of guard samples; application and use of seed standards and tolerances.

Practical

Structure of monocot and dicot seeds of important plant species; identification and handling of instruments used in seed testing laboratory; identification of seeds of weeds and crops; physical purity analysis of samples of different crops; estimation of seed moisture content (oven method); seed dormancy breaking methods requirements for conducting germination test, specifications and proper use of different substrata for germination; seed germination testing in different agri-horticultural crops; seedling evaluation; viability testing by tetrazolium test in different crops; seed and seedling vigour tests applicable in various crops; species & cultivar identification; genetic purity testing by chemical, biochemical and molecular methods; seed health testing for designated diseases, blotter methods, agar method and embryo count methods; testing coated/pelleted seeds.

Suggested Readings

- Agarwal RL. 1997. Seed Technology. Oxford & IBH.
- Agrawal PK & Dadlani M.1992. Techniques in Seed Science and Technology. 2nd Ed. South Asian Publ.
- Agrawal PK. (Ed.). 1993. Handbook of Seed Testing. Ministry of Agriculture, GOI, New Delhi.
- Copland LO & McDonald MB. 1996. Principles of Seed Science and Technology. Kluwer.
- ISTA 2006. Seed Testing Manual. ISTA, Switzerland.
- Martin C & Barkley D. 1961. Seed Identification Manual. Oxford & IBH.
- Tunwar NS & Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

SST 509 : SEED PHYSIOLOGY 1+1

Objective

To provide an insight into physiological processes governing seed quality and its survival.

Theory

UNIT I

Physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal regulation of seed development.

UNIT II

Seed germination; factors affecting germination; role of embryonic axis; growth hormones and enzyme activities, effect of age, size and position of seed on germination. Physiological processes during seed germination; seed respiration, breakdown of stored reserves in seeds, mobilization and inter- conversion pathways. Seed dormancy- types, significance, mechanism, endogenous and exogenous factors regulating dormancy, role of phytochrome and PGR, genetic control of dormancy.

UNIT III

Seed viability and longevity, pre and post-harvest factors affecting seed viability ; seed ageing ; physiology of seed deterioration ; lipid peroxidation and other viability theories; means to prolong seed viability; mechanism of desiccation sensitivity and recalcitrance with respect to seed longevity.

UNIT IV

Seed vigour and its concept, vigour test methods, factors affecting seed vigour, physiological basis of seed vigour in relation to crop performance and yield. Seed invigoration and its physiological and molecular control.

Practical

Proximate analysis of chemical composition of seed; methods of testing viability; kinetics of seed imbibition and solute leakage; seed germination and dormancy breaking methods; seed invigoration and priming treatments; accelerated ageing and controlled deterioration tests; enzymatic activities and respiration during germination and effect of accelerated ageing; vigour testing methods etc.

Suggested Readings

- Agrawal PK & Dadlani M. (Eds.). 1992. Techniques in Seed Science and Technology. South Asian Publ.
- Baskin CC & Baskin JM. 1998. Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination. Academic Press.
- Basra AS. 2006. Handbook of Seed Science and Technology. Food Product Press.
- Bench ALR & Sanchez RA. 2004. Handbook of Seed Physiology. Food Product Press.
- Bewley JD & Black M. 1982. Physiology and Biochemistry of Seeds in Relation to Germination. Vols. I, II. Springer Verlag.
- Bewley JD & Black M. 1985. Seed: Physiology of Seed Development and Germination. Plenum Press.
- Copeland LO & Mc Donald MB. 1995. Principles of Seed Science and Technology. 3rd Ed. Chapman & Hall.
- Khan AA. 1977. Physiology and Biochemistry of Seed Dormancy and Germination. North Holland Co.
- Kigel J & Galili G. (Eds.). Seed Development and Germination. Marcel Dekker.
- Murray DR. 1984. Seed Physiology. Vols. I, II. Academic Press.
- Sadasivam S & Manickam A. 1996. Biochemical Methods. 2nd Ed. New Age.

SST 510 : SEED PATHOLOGY **2+1**

Objective

To acquaint the students with principles and practices of seed health testing and management of seed borne diseases.

Theory

UNIT I

History and economic importance of seed pathology in seed industry and plant quarantine; terminology, important seed transmitted pathogens; seed microbes and their mode of action, detection techniques and identification of common seed borne pathogens.

UNIT II

Morphology and anatomy of typical monocotyledonous and dicotyledonous seeds; mode and mechanism of transmission of seed borne pathogens and microorganisms. Rate of transmission of major plant pathogens, microorganisms in relation to seed certification and tolerance limit; type of losses caused by seed- borne diseases.

UNIT III

Role of microorganisms in seed quality deterioration; management of seed- borne plant pathogens/diseases and procedure for healthy seed production; different seed health testing methods for detecting microorganisms; treatments to control seed borne diseases.

UNIT IV

Pest Risk Analysis (PRA) and disease free seed production, Sanitary & Phytosaintory (SPS) requirements in seed trade, International regulation (ISHI) in respect of seed health standards.

Practical

Different methods of examination of seeds to assess seed-borne microorganisms and to quantify infection percentage, detection of seed- borne fungi, bacteria and viruses, identification of storage fungi, control of seed borne diseases, seed treatment methods.

Suggested Readings

- Agarwal VK & Sinclair JB. 1997. Principles of Seed Pathology. Boca Raton. Karuna V. 2007. Seed Health Testing. Kalyani.
- Neergaard P. 1988. Seed Pathology. Mac Millan.

ST 511 : SEED ENTOMOLOGY 2+1

Objective

To apprise about the role of insects in seed production and their effect on seed quality during storage.

Theory

UNIT I

Principles of seed entomology; pollinator insects, insect pests and their classification based on mode of infestation etc.

UNIT II

Principles of insect pollination, role of pollinators in seed production. Augmenting quality seed production through honeybee pollination in crucifers and forage legumes. Plant protection measures in bee pollinated crops. Management of pollinators for hybrid seed production.

UNIT III

Major insect pests of principal crops and their management practices. Methods of insect pest control. Classes of pesticides, their handling and safe use on seed crops.

UNIT IV

Storage insect pests infecting seeds, their development and economic importance. Storage losses due to pests, control of storage pests, Management of storage insects pests, mites and rodents, seed sampling and loss estimation.

UNIT V

Principles of fumigation and their use, effect of different fumigants; preservatives and seed protectants on seed quality; Type of storage structures – domestic and commercial.

Practical

Collection and identification of insect-pollinators, collection and identification of important pests of stored seeds. Detection and estimation of pest infestation vis- a- vis loss of seed quality. Safe handing and use of fumigants and insecticides ; safety measures in fumigating and disinfecting , exposure period, aeration etc. the storage structures. Plant protection equipments, their operation and maintenance. Pesticides, its dose determination, preparation of solution and its application.

Suggested Readings

- Agarwal NA & Girish GK. 1977. An Introduction to Action Programme to Regress on Farm Storage Losses in India. FAO/NORAD Seminar on Farm Storage Grain in India, Nov. 29-Dec. 8, 1977.
- Anderson JA & Aleock AW. 1954. Storage of Cereal Grain & their Products. American Assoc. Cereal Chemists, St. Pauls, Minn.
- Cottong RT. 1963. Insect Pests of Stored Grain and Grain Products. Burgess Publ. Co., Minneopolis, Minn., USA.
- Monro 1969. Manual of Fumigation for Insect Control. FAO Rome Agril. Studies No. 79.
- Subramanyam B & Hagstrum DW. 1995. Interrelated Management of Insects in Stored Products. Marcel Dekker.

SST 512 : SEED PRODUCTION IN FORAGE, PASTURE AND GREEN MANURE CROPS 2+1

Objective

To apprise about the basic requirements and methods of quality seed production in forage, pasture and green manure crops.

Theory

UNIT I

Important pasture and forage legume crops in India; seed requirement and production; classification of forage, pastures and green manure crops; pollination behavior.

UNIT II

Factors influencing seed production; maintenance of varietal purity, generation systems of seed multiplication self pollinated crops; seed production in apomictic grasses.

UNIT III

Methods and techniques of seed production in important grasses, pastures, legumes and green manure crops; apomictic seed.

UNIT IV

Selection of seed production areas, influence of season, seed rate and spacing, sowing methods, direct seed sowing, transplanting, pelleting, fertilizer and manure requirement, isolation distance, weed control, pollination and seed setting, seed shattering, seed maturity and stage of harvest, seed collection, economics of seed production of important fodder crops.

UNIT V

Seed processing, seed treatment, seed storage, seed viability of these crops.

Practical

Study of flower structure, seed collection and identification, characteristics of forage, pastures and green manure crops; maturity indices for harvest, seed testing- sampling, purity, moisture, germination and dormancy, seed treatments.

Suggested Readings

- Farity DT & Hampton JC. 1997. Forage Seed Production. Vol. I. Temperate species. CABI.
- Froma J. 1997. Temperate Forage Legumes. CABI.
- Gutterridge RG. 1997. Forage Tree Legumes in Tropical Agriculture.CABI.
- Quality Declared Seed System. 2007. FAO Plant Production and Protection Publication No.185: FAO, Rome.

SST 513 : SEED STORAGE AND DETERIORATION 1+1

Objective

To provide understanding of the mechanism of seed ageing during storage, factors affecting it and its control.

Theory

UNIT I

Life span of seeds of plant species; classification of seeds on the basis of storage behaviour; orthodox and recalcitrant seeds; types of storage; kinds of seed storage (open, bulk, controlled, hermetic, germplasm, cryopreservation); soil seed bank; terminology; survival curve of seed.

UNIT II

Factors affecting seed storability- biotic and abiotic and pre- and post-
harvest factors affecting seed longevity; the effects of packaging materials, storage fungi and insects, seed treatment and fumigation and storage environmental conditions on seed storability; moisture equilibrium in seeds; hysteresis effect; thumb rules; selection of suitable areas/places for safe storage; prediction of relative storability and longevity of seed lots, viability equations and nomographs.

UNIT III

Concept of seed ageing and deterioration, its causes, symptoms, mechanisms and related theories; different changes associated with the loss of vigour and viability during storage; application of physiological and biochemical techniques for evaluation of seed ageing; genetics of seed viability; effect of seed ageing on crop performance; maintenance of viability and vigour during storage; seed amelioration techniques, mid storage corrections etc.

UNIT IV

Storage methods- requirement of storage facilities in India; types and storage structures available in the country and their impact on short and long term storage; methods of safe

seed storage including eco-friendly techniques used in various group of crops viz. cereals, pulses, oilseeds, fibers, forages and vegetables; operation and management of seed stores; fruit storage; viability loss during transportation and interim storage.

Practical

To study the effect of storage environmental factors (RH, SMC and temperature) on seed longevity; to study the effect of packaging materials, seed treatment and fumigation on storability; prediction of storability and longevity of seed-lots by using viability equations and nomographs; standardization of accelerated ageing (AA) technique for assessing the seed storability of various crops; estimation of carbohydrates, proteins, fats, enzyme activities, respiration rate and nucleic acids in fresh and aged seeds; use of eco-friendly products and amelioration techniques to enhance quality of stored seeds, visit to seed stores.

Suggested Readings

- Barton LV. 1961. Seed Preservation and Longevity. Burgess Publ.
- Basra AS. (Ed.). 1995. Seed Quality: Basic Mechanisms and Agricultural Implications. Food Products Press.
- Basra AS. 2006. Handbook of Seed Science and Technology. Food Product Press.
- Desai BB. 2007. Seed Handbook: Biology, Production, Processing and Storage. Marcel Dekker.
- Doijode SD. 2001. Seed Storage of Horticultural Crops. CBS.
- Justice OL & Bass LN. 1978. Principles and Practices of Seed Storage. Castle House Publ.
- Kharb RPS & Kharb P. 1977. Biochemical and Cytogenetical Changes During Storage. In: Seed Technology (Eds. BS Dahiya & KN Rai): pp. 160-168.
- McDonald MB & Roos EE. (Eds.). 1986. Physiology of Seed Deterioration. Paper No. 11, Crop Science Society of America, USA.
- Roberts EH. 1972. Viability of Seeds. Chapman & Hall.

SST 514 : SEED MARKETING AND MANAGEMENT 1+1

Objective

To apprise students about the seed supply system, concepts and principles of effective marketing of seed and strengths and weaknesses of the seed sector.

Theory

UNIT I

Importance and promotion of quality seed, formal and informal seed supply systems. Basic concepts of marketing with special reference to seed; importance and scope of seed industry in India, major constraints/problems in seed industry/seed sector role of seed association / federation in seed trade.

UNIT II

Demand and supply of seed; Role of seed replacement rate (SRR), seed multiplication ratio (SMR), cost of production and returns; determining seed needs; seed pricing and price policy, seed processing and /packaging, demand forecasting.

UNIT III

Seed marketing intelligence and product mix, sales promotion, distribution channels, marketing costs and margins.

UNIT IV

Salient features of national seed policies, role of various sectors/agencies in efficient seed marketing, quality control and assurance programme. Responsibilities of seed companies and dealers under Seed Act, EXIM policies for seed trade etc.

Practical

Statutory requirements in seed business including R&D, estimation of cost of seed production, marketing costs and margins of seeds of different crops, case studies to compare public & private sectors in different conditions, impact analysis., seed pricing, cost benefit ratio, economic feasibility of seed industry etc.

Suggested Readings

- Kohls RL & Uhl JN. 1980. Marketing of Agricultural Products. MacMillan.
- Kundu KK & Suhag KS. 2006. Teaching Manual on Seed Marketing and Management. Department of Agricultural Economics CCS HAU Hisar.
- Venugopal P. 2004. State of Indian Farmers: A Millennium Study. Vol.VIII. Input Management. Academic Foundation, Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi.

SST 515 : EMERGING TRENDS IN SEED QUALITY ENHANCEMENT 1+1

Objective

To update knowledge on seed quality enhancement technologies and their application.

Theory

UNIT I

Concept and significance of seed quality enhancement; physical, chemical and pesticidal seed treatments, history, principles and methods of seed treatment, methodology and factors affecting seed enhancement treatments.

UNIT II

Seed priming: physiological and biochemical basis, types of priming technology, biochemical and molecular changes associated, pregermiantion, film coating and pelleting, seed tapes, seed mats, seed colouring, biopriming.

UNIT III

Synthetic seeds – Aim and scope for synthetic seeds, historical development, somatic embryogenesis, somaclonal variation and their control, embryo encapsulation systems, hardening of artificial seeds, cryo- preservation, storage of artificial seeds, desiccation tolerance, use of botanicals in improving seed quality etc.

Practical

Seed treatments – methods and techniques, equipments required for seed treatment, film coating; seed invigoration/priming - hydration and dehydration, PEG priming, solid matrix priming, bio priming, effects of priming; methods for hydrogel encapsulation of artificial endosperm, hydrophobic coating etc.; protocols for production of synthetic seeds, Visit to leading Seed Companies to study the seed treatment processes.

Suggested Readings

- Basra AS. (Ed.). 1995. Seed Quality: Basic Mechanisms and Agricultural Implications. Food Product Press, NY.
- Basra AS. 2006. Handbook of Seed Science and Technology. Food Product. Press, NY
- Bench ALR & Sanchez RA. 2004. Handbook of Seed Physiology. Food Product Press, NY/ London.
- Copland LO & McDonald MB. 2004. Seed Science and Technology. Kluwer Acad.
- Kalloo G, Jain SK, Vari AK & Srivastava U. 2006. Seed: A Global Perspective. Associated Publishing Company, New Delhi.

SST 516 : GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE 2+1

Objective

To provide information about collection, germplasm exchange, quarantine, maintenance and use of plant genetic resources including genetically modified plants.

Theory

UNIT I

History and importance of germplasm exploration; Distribution and extent of prevalent genetic diversity; Phyto-geographical regions/ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora.

UNIT II

Concept of population and gene pool; Variations in population and their classification; Gene frequencies in populations, rare and common alleles; Gene pool sampling in self and cross pollinated and vegetatively propagated species; Non-selective, random and selective sampling strategies; Strategies and logistics of plant exploration and collection; Coarse and fine grid

surveys; Practical problems in plant exploration; Use of *in vitro* methods in germplasm collection.

UNIT III

Ethnobotanical aspects of PGR; Crop botany, farming systems, collecting wild relatives of crop plants; Collection and preservation of specimens; Importance and use of herbaria and preparation of herbarium specimens.

UNIT IV

Post-exploration handling of germplasm collections; Present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum, sesame, *Brassica*, okra, eggplant, cotton, mango etc; approaches for collection including indigenous knowledge.

UNIT V

History, principles, objectives and importance of plant introduction; Pre- requisites, conventions, national and international legislations and policies on germplasm collection and exchange; Documentation and information management; Plant quarantine- introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India; Pest risk analysis, pest and pathogen information database; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses, phytoplasma etc.).

UNIT VI

Detection and identification of pests including use of recent techniques like ELISA, PCR etc., Symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities; Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust.

UNIT VII

Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

Practical

Plant exploration and collection; Techniques of coarse and fine grid surveys; Identification of wild relatives of crop plants- Example of collection, cataloguing and preservation of specimens; Sampling techniques
of plant materials; Visiting ports, airports to study the quarantine regulations; Techniques for the detection of insects, mites, nematodes, bacteria, weeds, pathogens and viruses on seed and planting materials and salvaging; Use of visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques(controlled green houses/growth chambers, etc); Detection of GMOs and GEPs; Study of post-entry quarantine operation, seed treatment and other prophylactic treatments.

Suggested Readings

- Briggs D. 1997. Plant Variation and Evolution. Science Publ.
- Cronquist AJ. 1981. An Integrated System of Classification of Flowering Plants. Columbia Univ. Press.
- Dhillon BS, Varaprasad KS, Kalyani S, Singh M, Archak S, Srivastava U & Sharma GD. 2001. Germplasm Conservation A Compendium of Achievements. NBPGR, New Delhi.
- di Castri F & Younes T. 1996. Biodiversity Science and Development: Towards New Partnership. CABI & International Union for Biol. Sci. France.
- Gurcharan Singh. 2004. Plant Systematics: An Integrated Approach. Science Publ.
- Lawrence GMH. (Ed.). 1951. Taxonomy of Vascular Plants. London.
- Paroda RS & Arora RK. 1991. Plant Genetic Resources Conservation and Management Concepts and Approaches. IPGRI Regional office for South and South Asia, New Delhi.
- Pearson LC. 1995. The Diversity and Evolution of Plants. CRC Press.
- Singh BP. 1993. Principles and Procedures of Exchange of Plant Genetic Resources Conservation and Management. Indo-US PGR Project Management.
- Sivarajan VV. 1991. Introduction of Principles of Plant Taxonomy. Science Publ.
- Stace CA. Plant Taxonomy and Biosystematics 2nd Ed. Cambridge Univ. Press.

- Takhrajan A. 1997. Diversity and Classification of Flowering Plants. Columbia Univ. Press.
- Wiersema JH. 1999. World Economic Plants: A Standard Reference. Blanca Leon.

SST 517 : SEED PRODUCTION IN FRUITS AND PLANTATION CROPS 2+1

Objective

To impart comprehensive knowledge of seed production in horticultural crops with adequate practical training

Theory

UNIT I

Introduction: modes of propagation in fruits and plantation crops. Floral biology of these plant species; classification of medicinal and horticultural crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops.

UNIT II

Fruits and Plantetion Plants; classification based on growth cycle, reproduction and pollination behavior; nursery requirement, planning and management; technology for quality seed production in important Fruit and Plantation species; development of hybrids and their seed production technology.

UNIT III

Fruit and Plantation Crops: role of seed in perennial plant species; classification based on reproduction and pollination behavior; polyembryony and its significance; nursery requirement, planning and management; clonal propagation and multiplication in tropical, sub-tropical and temperate fruits and plantation crops; seed orchards; seed collection, extraction and processing.

UNIT IV

IPR issues with special reference to floral and plantation crops.

Practical

Selection of suitable areas/locations for high quality seed/planting material production; study of floral biology of fruits and plantation crops; exercises on emasculation and pollination; seed extraction methods and their effect on quality of fruit; seed production technology of varieties and hybrids; seed collection and extraction in fruit and plantation crops.

Suggested Readings

- Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH.
- Desai BB, Katecha, PM & Salunke DK.1997. Seed Hand Book: Biology, Production, Processing and Storage. Marcel Dekker.
- Desai BB. 2004. Seeds Handbook. Marcel Dekker.
- Doijode SD. 2001. Seed Storage of Horticultural Crops. CBS.
- George RAT. 1980. Vegetable Seed Technology. A Technical Guide to Vegetable Seed Production, Processing, Storage and Quality Control. FAO, Rome.
- Hartman HT & Kester DE. 2000. Plant Propagation: Principles and Practices. Prentice Hall.
- ICAR. Hand Book of Horticulture. ICAR Publ.
- Kelly AF & George RAT. (Eds.).1998. Encyclopedia of Seed Production of World Crops. John Wiley & Sons.
- McDonald MB Jr & Copeland LO. 1997. Seed Production of Crops: Principles and Practices. Chapman & Hall.
- Salunkhe DK, Desai BB & Bhat RN. 1987. Vegetable and Flower Seed Production. Agricole Publ. Academy.
- Singh SP. 2001. Seed Production of Commercial Vegetables.Agrotech.
- Singhal NC. 2003. Hybrid Seed Production in Field Crops. Kalyani.

SST 601 : HYBRID SEED PRODUCTION 1+ 1

Objective

To provide a comprehensive knowledge and practical exposure to hybrid seed production in field crops and vegetables.

Theory

UNIT I

Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in agricultural, horticultural and other crop plants for crop improvement.

UNIT II

Pre requisites for hybrid seed production; mechanisms and management of pollination in autogamous and allogamous crops; genetic constitution of varieties, hybrids and basic principles in seed production.

UNIT III

Techniques of hybrid seed production - emasculation and crossing: use of self-incompatibility, modification of sex; types of male sterility and exploitation in hybrid development and its use in hybrid seed production; development and maintenance of A, B and R lines.

UNIT IV

Fertility restoration; use of chemical hybridizing agents, problems of non synchrony in flowering of parental lines and methods to overcome; planting ratios and population density in relation to hybrid seed yield; salient features of hybrid seed production of various crops viz., rice, sorghum, bajra, maize, sunflower, cotton and other major vegetables.

Practical

Methods of hybrid seed production in major agricultural and horticultural crops; planting of rows/blocks of parental lines and manipulations for achieving flowering synchrony for production of hybrid seeds, maintenance of A, B and R lines and production of breeder seed; stable diagnostic characteristics of parental lines and their hybrids; genetic purity tests; determination of cost of hybrid seed production of various crops; visit to seed production plots etc.

Suggested Readings

- Basra AS. 2000. Heterosis and Hybrid Seed Production in Agricultural Crops. Food Product Press.
- McDonald MB & Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall.
- Singhal NC. 2003. Hybrid Seed Production. Kalyani Publishers.

SST 602 : IN SITU AND EX SITU CONSERVATION OF GERMPLASM 2+1

Objective

To impart knowledge on the methods of germplasm conservation.

Theory

UNIT I

Concept of natural reserves and natural gene banks, *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ* conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

UNIT II

Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, *perma-frost* conservation, guidelines for sending seeds to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling ,clonal repositories, genetic stability under long term storage condition.

UNIT III

In vitro storage, maintanence of *in vitro* culture under different conditions, *in vitro* bank maintanence for temporate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplast and callus cultures, pollen culture, micropropagation techniques, problems , prospects of *in vitro* gene bank.

UNIT IV

Cryopreservation- procedure for handling seeds of orthodox and recalcitrants-cryoprotectants, dessication, rapid freezing, slow freezing, vitrification techniques, encapsulation/dehydration techniques, national facilities, achievements, application of cryopreservation in agriculture, horticulture and forestry crops.Problems and prospects; challenges aheads.

Practical

In situ conservation of wild species –case studies at national and international levels- *ex situ* techniques for active and long-term conservation of collections- Preparation and handling of materials, packaging, documentation; design of cold storage modules- Conservation protocols for recalcitrant and orthodox seeds; Cytological studies for assessing genetic stability, *in vitro* cultures- embryo,cell/suspension cultures,pollen cultures, study of cryotank facility and vitrification techniques, visit to NBPGR/NBAGR -study using fruit crops and other horticultural crops.

Suggested Readings

- Ellis RH & Roberts EH & White Head J. 1980. A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks. FAO / IBPGR Pl. Genet. Resources News 41-3-18.
- Frankel OH & Hawkes JG. 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press, Cambridge.
- Simmonds, N.W. 1979. Principles of Crop Improvement Longman.
- Westwood MN. 1986. Operation Manual for National Clonal Germplasm Repository Processed Report. USDA-ARS and Orgon State Univ. Oregon, USA.
- Withers LA. 1980. Tissue Culture Storage for Genetic Conservation. IBPGR Tech. Rep. IBPGR, Rome, Italy.

SST 603 : TESTING FOR GENUINENESS & PURITY OF CULTIVARS 1+1

Objective

To provide hands-on training on various field and laboratory methods of testing cultivar purity.

Theory

UNIT I

Objective of cultivar purity test, general principles and methods involved. Use and limitations of laboratory, green house and field plot methods in determination of genuineness of cultivars; a case study in hybrid cotton, reporting of results and inference.

UNIT II

Chemical-biochemical tests for species and cultivar purity: phenol test, seed and seedling tests, electrophoretic analysis of seed protein, isozymes etc, use of chromatography for analysis of secondary compounds etc.

UNIT III

DNA finger printing (RAPD, SSR, AFLP etc) and their use in varietal purity testing and registration of new varieties.

UNIT IV

Use of computer-based machine vision (MVT) for varietal identification and purity testing.

Practical

Chemical and biochemical tests for species and cultivar purity: phenol test, seed and seedling tests, electrophoretic analysis of seed protein and isozymes, DNA fingerprinting using PCR techniques, useof chromatography for analysis of secondary compounds.

Suggested Readings

- Basra AS. (Ed.). 1995. Seed Quality: Basic Mechanisms and Agricultural Implications. Food Product Press.
- ISTA 2006. Handbook of Variety Testing. International Seed Testing Association, Switzerland.

SST 604 : DUS TESTING FOR PLANT VARIETY PROTECTION 2+1

Objective

To provide a comprehensive understanding of DUS testing, its conduct and significance to PVP.

Theory

UNIT I

Genesis of plant variety protection (PVP); International Union for Protection of New Varieties of Plants (UPOV) and its functions; General agreements on Tariff and Trades (GATT) agreement in relation to protection of plant varieties; Protection of Plant Varieties and Farmers' Rights (PPV &FR) Act, 2001; PPV&FR rules, 2003.

UNIT II

Criteria for protection of new varieties of plants; principles and procedures of Distinctness, Uniformity and Stability (DUS) testing; test guidelines, planting material, duration, testing options, varieties ofcommon knowledge, reference collection, grouping of varieties, types and categories of characters; technical questionnaire.

UNIT III

Assessment of DUS characters based on morphological, biochemical and molecular markers; statistical procedures; computer software for use in DUS testing; impact of PVP on growth of seed industry; practical exercise of DUS testing in rice, wheat, pearl- millet, maize, rose and cauliflower.

Practical

Morphological description of plant parts and plant; character expression and states, recording observation and interpretation of data; chemical tests and markers applicable for DUS tests and case study of selected crops.

Suggested Readings

- Chakrabarty SK, Prakash S, Sharma SP & Dadlani M. 2007. Testing Of Distinctiveness, Uniformity And Stability For Plant Variety Protection. IARI, New Delhi.
- Joshi AK & Singh BD. 2004. Seed Science And Technology. Kalyani.
- The Protection Of Plant Varieties And Farmers' Rights Act 2001. Bare Act With Short Notes 2006. Universal Law Publ.

SST 605 : ADVANCES IN SEED SCIENCE RESEARCH 1+0

Objective

To provide knowledge on the advances in various aspects of seed science & their application in seed technology.

Theory

UNIT I

Physiological and molecular aspects of seed development and control of germination and dormancy; gene expression during seed development; desiccation and stress tolerance and conservation; prediction of seed dormancy and longevity using mathematical models; structural changes in membranes of developing seeds during acquisition of desiccation tolerance; dehydration damage and repair in imbibed seeds, seed biotechnology; genetic analysis and QTL mapping of germination traits; seed ageing and ethylene production; recent accomplishments in seed enhancement research and application of nanotechnology.

UNIT II

Modern techniques for identification of varieties and hybrids; principles and procedures of electrophoresis, machine vision technique, DNA fingerprinting and other molecular techniques and their utilization; techniques for improving seed quality; proteomic analysis; seed priming, coating, pelleting and synthetic seeds; GM seeds and their detection, terminator

technology (GURT).

UNIT III

Detection and identification of seed borne fungi, bacteria, viruses, nematodes and insect pests through advanced techniques like ELISA, PCR based techniques etc.

UNIT IV

Seed production of self incompatible and apomictic plant species; recent developments in seed laws, policies and seed certification system in India and its comparison with OECD seed certification schemes; IPR systems and PVP internationally.

Suggested Readings

- Bench ALR & Sanchez RA. 2004. Handbook of Seed Physiology. Food Product Press.
- Black M & Bewley JD. (Eds.). 2000. Seed Technology and its Biological Basis. Sheffield Academic Press.
- Nicolas G, Bradford KJ, Come D & Pritchard HW. 2003. The Biology of Seeds, Recent Research Advances. CABI.

AGRICULTURAL METEOROLOGY

AGM 501 : FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY 2+1

Objective

To impart theoretical and practical knowledge of physical processes occurring in atmosphere and techniques used in meteorology.

Theory

UNIT I

Solar radiation and laws of radiation; greenhouse effect, albedo, and heat balance of the earth and atmosphere; variation of pressure and temperature with height, potential temperature, pressure gradient, cyclonic and anticyclonic motions; geostropic and gradient winds; equations of motion; general circulation, turbulence, vorticity, atmospheric waves.

UNIT II

Gas laws, laws of thermodynamics and their application to atmosphere; water vapour in the atmosphere, various humidity parameters and their interrelationships; vapour pressure, psychrometric equation, saturation deficit, stability and instability conditions in the atmosphere.

UNIT III

Lapse rates-ascent of dry and moist air, condensation; clouds and their classification; evaporation and rainfall; the hydrological cycle; precipitation processes, artificial rainmaking, thunderstorms and dust storm; haze, mist, fog, and dew; air masses and fronts; tropical and extra-tropical cyclones.

UNIT IV

Effect of earth's rotation on zonal distribution of radiation, rainfall,
temperature, and wind; the trade winds, equatorial trough and its movement; the SE Asia monsoon.

UNIT V

Crop weather charts, calenders and diagrams; weather forecasting importance, types, tools, and modern techniques of weather forecasting; El Nino, la Nino and ENSO.

UNIT VI

Instruments for measurement of meteorological elements; agromet observatory; measures of central tendency and dispersion, correlation, regression, moving average probability and their distribution function; water budgeting; synoptic, numerical, graphical, spatial analysis of weather systems and charts technique.

Practical

- Agromet observatory- different classes of observatories (A, B, C)
- Site selection and installation procedures for meteorological instruments

- Measurement of weather parameters.
- Reading and recording, calculation of daily, weekly, monthly means.
- Totals of weather data.
- Climatic normals, weather chart preparation and identification of low pressure systems and ridges.
- Statistical technique for computation of normals, moving average, marton chain model etc.

Suggested Readings

- Barry RG & Richard JC. 2003. Atmosphere, Weather and Climate. Tailor & Fransics Group.
- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- Ghadekar SR. 2001. Meteorology. Agromet Publ.
- McIlveen R. 1992. Fundamentals of Weather and Climate. Chapman & Hall.
- Petterson S. 1958. Introduction to Meteorology. McGraw Hill.
- Trewartha Glenn T. 1954. An Introduction to Climate. McGraw Hill.

AGM 502 : FUNDAMENTALS OF AGRICULTURAL METEOROLOGY 2+1

Objective

To impart the theoretical and practical knowledge of physical processes occurring in relation to plant and atmosphere with advanced techniques.

Theory

UNIT I

Meaning and scope of agricultural meteorology; components of agricultural meteorology; role and responsibilities of agricultural meteorologists.

UNIT II

Importance of meteorological parameters in agriculture; efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation; basic principles of water balance in ecosystems; soil-water balance models and water production functions.

UNIT III

Crop weather calendars; weather forecasts for agriculture at short, medium and long range levels; agromet advisories, preparation, dissemination and economic impact analysis; use of satellite imageries in weather forecasting; synoptic charts and synoptic approach to weather forecasting.

UNIT IV

Concept, definition, types of drought and their causes; prediction of drought; crop water stress index, crop stress detection; air pollution and its influence on vegetation.

UNIT V

Meteorological aspects of forest fires and their control; concepts of mechanistic and deterministic models; general features of dynamical and statistical modeling techniques; weather data and phenology-based approaches to crop modeling; validation and testing of models.

UNIT VI

Climatic change, green house effect, CO_2 increase, global warming and their impact on agriculture; concept and types of drought; climate classification, agro-climatic zones and agro-ecological regions of India.

Practical

- Preparation of crop weather calendars
- Development of simple regression models for weather, pest and disease relation in different crops.
- Preparation of weather based agro-advisories
- Use of automated weather station (AWS)

Suggested Readings

- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- Kakde JR. 1985. Agricultural Climatology. Metropolitan Book Co.
- Varshneya MC & Pillai PB. 2003. Text Book of Agricultural Meteorology. ICAR.

AGM 503 : MICROMETEOROLOGY 2+1

Objective

To impart the theoretical and practical knowledge of physical processes occurring in lower atmosphere.

Theory

UNIT I

Properties of atmosphere near the earth's surface; exchange of mass momentum and energy between surface and overlaying atmosphere, exchange coefficient, similarity hypothesis, shearing stress, forced and free convection**.**

UNIT II

Molecular and eddy transport of heat, water vapour and momentum, frictional effects, eddy diffusion, mixing; temperature instability, air pollution; microclimate near the bare ground, unstable and inversion layers, variation in microclimate under irrigated and rainfed conditions, soil moisture and temperature variation with depth; Richardson number, Raymonds analogy, Exchange coefficients.

UNIT III

Micrometeorology of plant canopies; distribution of temperature, humidity, vapour pressure, wind and carbon dioxide; modification of microclimate due to cultural practices, intercropping; radiation distribution and utilization by plant communities, leaf temperature and its biological effects; influence of topography on microclimate; shelter belts and wind breaks, microclimate in low plant area of meadows and grain fields, microclimate within forests, glass house and plastic house climates; instruments and measuring techniques in micrometeorology.

UNIT IV

Effects of ambient weather conditions on growth, development and yield of crops; measurement of global and diffuse radiation; measurement of albedo over natural surfaces and cropped surfaces; net radiation measurement at different levels; PAR distribution in plant canopies and interception; wind, temperature and humidity profiles in (a) short crops and (b) tall crops; energy balance over crops and LAI and biomass estimation; remote sensing in relation to micrometeorology.

Practical

- Micrometerological measurements in crop canopies
- Quantification of crop microclimate
- Determination of ET and its computation by different methods

Suggested Readings

- Arya S Pal. 1988. Introduction to Micrometeorology. Academic Press.
- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- Gates DM. 1968. Energy Exchange in the Biosphere. UNESCO.
- Goudriaan J. 1983. Crop Micrometeorology: A Simulation Study. Scientific Publ.
- Grace J. 1983. Plant Atmospheric Relationships: Outline Studies in Ecology. Chapman & Hall.
- Gupta PL & Rao VUM. 2000. Practical Manual on Micrometeorology. Dept. of Agril. Meteorology, CCS HAU Hisar, India.
- Jones HG. 1992. Plants and Micriclimate. Cambridge Univ. Press. Munn RE. 1970. Biometeorological Methods. Academic Press.
- Rosenberg NJ. 1974. Microclimate – The biological Environmet. John Wiley & Sons.
- Sellers W. 1967. Physical Climatology. The University of Chicago Press.

AGM 504 : AGRO-METEOROLOGICAL MEASUREMENTS AND INSTRUMENTATION 1+2

Objective

To impart the theoretical and practical knowledge of instruments/equipments used for measurement of agro-meteorological variables.

Theory

UNIT I

Fundamentals of measurement techniques; theory and working principles of barometers, thermometers, psychrometers, hair hygrometer, thermo- hygrograph; exposure and operation of meteorological instruments/ equipments in agromet observatories.

UNIT II

Radiation and temperature instruments: working principles of albedometer, photometer, spectro-radiometer, sunshine recorder, dew recorder, quantum radiation sensors, pressure bomb apparatus, thermographs, and infra-red thermometer.

UNIT III

Precipitation and dew instruments: working principles of rain gauge, self recording rain gauge, Duvdevani dew gauges.

UNIT III

Wind instruments: working principles of anemometer, wind vane, anemograph.

UNIT IV

Evapotranspiration and photosynthesis instruments: working principles of lysimeters, open pan evaporimeters, porometer, photosynthesis system, leaf area meter.

UNIT V

Soil thermometers, soil heat flux plates, instruments for measuring soil moisture.

UNIT VI

Automatic weather station – data logger and sensors, nano-sensors for measurement of weather variables; computation and interpretation of data.

Practical

- Working with the above instruments in the meteorological observatory taking observations of relevant parameters
- Computation interpretation of the data

Suggested Readings

- Anonymous. 1987. Instructions to Observers at Surface Observatories. Part I, IMD, New Delhi.
- Byers HR. 1959.General Meteorology. McGraw Hill.
- Ghadekar SR. 2002. Practical Meteorology: Data Acquisition Techniques, Instruments and Methods. Agromet Publ.
- Middleton WE & Spilhaws AF. 1962. Meteorological Department. University of Toronto Press.
- Tanner CB. 1973. Basic Instrumentation and Measurements for Plant Environment and Micrometeology. University of Wisconsin, Madison.

AGM 505 : SOIL WATER BALANCE CLIMATOLOGY 2+1

Objective

To impart the theoretical and practical knowledge of ET estimation and measurements.

Theory

UNIT I

Basic Laws of radiation; radiation interaction with plant environment; energy balance in atmosphere, crop canopy.

UNIT II

Atmosphere near the ground; laminar and turbulent flows; wind profile near the ground.

UNIT III

Theories of evapotranspiration and their comparison; aerodynamic, eddy correlation, energy balance, water balance and other methods, their application under different agroclimatic conditions; concepts of potential, reference and actual evapotranspiration - modified techniques.

UNIT IV

Influence of microclimatic, plant, soil and cultural factors; techniques of lysimetry in measuring actual evapotranspiration.

UNIT IV

Yield functions; water use efficiency and scheduling of irrigation based on evapotranspiration; water use efficiency and antitranspirants, Kc values and their use, dry matter yield ET functions; radiation instruments; advanced techniques for measurement of radiation and energy balance; computation of K_C values and their use; estimation of evapotranspiration through satellite imageries – MODIS, TERRA, AQUA, AVHRR, NOVA etc.; modeling for potential ET & reference ET, and ET through remote sensing.

Practical

- Measurement and evaluation of radiation components
- Computation and comparison of evapotranspiration by different methods - energy balance method, aerodynamic method, Penman method, remote sensing and other methods
- Measurement of wind and temperature profiles near the ground

Suggested Readings

- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- Burman R & Pochop LO. 1994. Evaporation, Evapotranspiration and Climatic Data. Elsevier.
- Grace J.1983. Plant Atmospheric Relationships: Outline Studies in Ecology. Chapman & Hall.
- Mavi HS & Graeme J Tupper 2004. Agrometeorology: Principles and Applications of Climate Studies in Agriculture. The Haworth Press.
- Murthy VRK. 2002. Basic Principles of Agricultural Meteorology. BS Publ.
- Ram Niwas, Diwan Singh & Rao VUM. 2000. Pratical Manual on Evapotranspiration. Dept. of Agril. Meteorology, CCS HAU Hisar.
- Rosenberg NJ, Blad BL & Verma SB. 1983. Microclimate – The Biological Environment. John Wiley & Sons.

AGM 506 : CROP WEATHER MODELS 1+2

Objective

To impart the theoretical and practical knowledge of various models for estimation of crop weather responses.

Theory

UNIT I

Principles of crop production; evaluation of crop responses to weather elements; impact of natural and induced variability of climate on crop production.

UNIT II

Empirical and statistical crop weather models their application with examples; regression models- incorporating weather, soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models; crop simulation models, e. g. CERES, WOFOST, SPAW, RESCAP, WTGROW etc.; forecasting of pests and diseases; verification, calibration and validation of models.

Practical

- Working with statistical and simulation models, DSSAT models, BRASSICA, RESCAP etc.

Suggested Readings

- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- DeWit CT, Brouwer R & de Vries FWTP. 1970. The Simulation of Photosynthetic Systems. pp. 7-70. In. Prediction and Measurement of Photosynhetic Activity. Proc. Int. Biological Programme Plant Physiology Tech. Meeting Trebon PUDOC. Wageningen.
- Duncan WG. 1973. SIMAI- A Model Simulating Growth and Yield in Corn. In: The Application of Systems Methods to Crop Production (D.N. Baker, Ed.). Mississippi State Univ. Mississipi.
- Frere M & Popav G. 1979. Agrometeorological Crop Monitoring and Forecasting. FAO.
- Hanks RJ. 1974. Mode for Predicting Plant Yield as Influenced by Water Use. Agron. J. 66: 660-665.

❖ Keulen H Van & Seligman NG. 1986. Simulation of Water Use, Nitrogen Nutrition and Growth of a Spring Wheat Crop. Simulation Monographs. PUDOC, Wageningen.

AGM 507 : WEATHER MODIFICATION AND RISK MANAGEMENT STRATEGIES 2+0

Objective

To impart the theoretical and practical knowledge of weather modification techniques with risk management strategies.

Theory

UNIT I

Historical reviews of weather modification, present status of weather modification for agriculture; atmospheric composition and green house effect.

UNIT II

Theories of weather modification; scientific advances in clouds and electrical behavior of clouds; hails suppression, dissipation of fog, modification of frost intensity and severe storms; shelter belts and wind breaks, mulches and anti-transpirants; protection of plants against climatic hazards; air and water pollution; meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses etc.

UNIT III

Risks in agricultural production, history of weather and climate as accepted risk factors in agriculture in the continent/region/country/sub-region concerned and the related documented risk concepts; history and trends of defense strategies towards such risks in the samecontinent region/country/sub-region; preparedness for weather and climate risks.

UNIT IV

Risks of droughts; monitoring, prediction and prevention of drought; drought proofing and management; modern tools inlcuidng remote sensing and GIS in monitoring and combating droughts.

UNIT VI

Risk characterization - definitions and classification of risks; characterization of weather and climate related risks in agriculture; water related risks; radiation/heat related risks; air and its movement related risks; biomass related risks; social and economic risk factors related to weather and climate.

UNIT VII

Approaches and tools to deal with risks - history of methods for weather and climate related risk assessments in the continent/region/country/sub- region concerned and their documented evidence of application to agricultural/farming systems; strategies of dealing with risks- mitigating practices before occurrence; preparedness for the inevitable; contingency planning and responses; disaster risk mainstreaming.

UNIT VIII

Perspectives for farm applications - farm applications not yet dealt with, such as making risk information products more client friendly and transfer of risk information products to primary and secondary users of such information; heterogeneity of rural people in education, income, occupation and information demands and consequences for risk information products and their transfer; livelihood-focused support, participation and community perspectives; challenges for developing coping strategies including transferring risks through insurance schemes.

UNIT IX

Challenges to coping strategies - combining challenges to disaster risk mainstreaming, mitigation practices, contingency planning and responses, basic preparedness; preparedness approaches reducing emergency relief necessities; the role that insurances can play in risk spreading and transfer; quantification of risk in agricultural systems associated with weather and climate; methods for risk assessment and application to agricultural systems of local and regional interest; application of risk management approaches to problems associated with weather and climate problems; application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.

Suggested Readings

- Anonymous 2003. Critical Issues in Weather Modification Research Board of Atmoshperic Science and Climate. National Research Council, USA.
- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- Chritchfield HJ. 1994. General Climatology. Prentice Hall. Lenka D. 1998. Climate, Weather and Crops in India. Kalyani.
- Mavi HS & Graeme J Tupper 2004. Agrometeorology: Principles and Applications of Climate Studies in Agriculture. The Haworth Press.
- Mavi HS. 1994. Introduction to Agrometeorology. Oxford & IBH.
- Menon PA. 1989. Our Weather. National Book Trust.
- Pearce RP. 2002. Meteorology at the Millennium. Academic Press.
- Rosenberg NJ, Blad BL & Verma SB. 1983. Microclimate – The Biological Environment. John Wiley & Sons.
- Samra JS, Pratap Narain, Rattan RK & Singh SK. 2006. Drought Management in India. Bull. Indian Society of Soil Science 24, ISSS, New Delhi.

AGM 508 : PRINCIPLES OF REMOTE SENSING AND ITS APPLICATIONS IN AGRICULTURE 2+1

Objective

To impart the theoretical and practical knowledge of remote sensing principles and their use to estimate of agro-meteorological variables.

Theory

UNIT I

Basic components of remote sensing- signals, sensors and sensing systems; active and passive remote sensing.

UNIT II

Characteristics of electromagnetic radiation and its interaction with matter; spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions.

UNIT III

Imaging and non-imaging systems; framing and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance.

UNIT IV

Data acquisition system, data preprocessing, storage and dissemination; digital image processing and information extraction.

UNIT V

Microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS.

UNIT VI

Digital techniques for crop discrimination and identification; crop stress detection - soil moisture assessment, inventory of ground water and satellite measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation.

UNIT VII

Soil resource inventory; land use/land cover mapping and planning; integrated watershed development; crop yield modeling and crop production forecasting.

Practical

- Acquisition of maps
- Field data collection
- Map and imagery scales
- S/W and H/W requirements and specifications for remote sensing
- Data products, their specifications, media types, data inputs, transformation, display types, image enhancement
- Image classification methods
- Evaluation of classification errors
- Crop discrimination and acreage estimations

- Differentiation of different degraded soils
- Time domain reflectometry
- Use of spectrometer and computation of vegetation indices
- Demonstration of case studies
- Hands on training

Suggested Readings

- ❖ Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- ❖ Colwell RN. (Ed.). Manual of Remote Sensing. Vols. 1, II. Am. Soc. Photogrammetry, Virginia.
- ❖ Curan PJ. Principles of Remote Sensing. ELBS/Longman.
- ❖ Georg Joseph 2005. Fundamentals of Remote Sensing. University Press (India).
- ❖ Jain AK. 1989. Fundamentals of Digital Image Processing, Prentice Hall of India.
- ❖ Narayan LRA. 1999. Remote Sensing and its Applications. Oscar Publ.
- ❖ Patel AN & Surender Singh 2004. Remote Sensing: Principles and Applications. Scientific Publ.

AGM 509 : APPLIED AGRICULTURAL CLIMATOLOGY 1+2

Objective

To impart the theoretical and practical knowledge of computation of different bio-parameters and their applications in the agriculture.

Theory

UNIT I

Climatic statistics: measures of central tendency and variability, skewness, kurtosis, homogeneity, correlation, regression and moving averages; probability analysis using normal, binomial, Markov-chain and incomplete gamma distribution; parametric and non parametric tests; assessment of frequency of disastrous events.

UNIT II

Hydrological cycle: precipitation intensity, evaporation, infiltration, runoff, soil storage and hydrological balance.

UNIT III

Climatic water budget: potential and actual evapotranspiration and their computation; measurement of precipitation, calculation of water surplus and deficit; computation of daily and monthly water budget and their applications; assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications.

UNIT IV

Thermal indices and phenology: cardinal temperatures; heat unit and growing degree day concepts for crop phenology, crop growth and development; insect-pest development; crop weathercalendars; agroclimatic requirement of crops.

UNIT V

Bioclimatic concepts: evaluation of human comfort, comfort indices (temperature, humidity index and wind chill) and clothing insulation; climate, housing and site orientation; climatic normals for animal production.

Practical

- Use of statistical approaches in data analysis
- Preparation of climatic water budget
- Estimation of agro-meteorological variables using historical records
- Degree day concept and phenology forecasting and preparation of crop calendar
- Evaluation of radiation, wind and shading effects in site selection and orientation
- Study of weather-pest and disease interactions, calculation of continentality factors; calculation of comfort indices and preparation of climograph.

Suggested Readings

- ❖ Anonymous 1980. ICRISAT Climatic Classification – A Consultation Meeting. ICRISAT.
- ❖ Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- ❖ Lal DS. 1989. Climatology. Chaitanya Publ. House.

- Mather JR. 1977. Work Book in Applied Climatology. Univ. of Delware, New Jersey.
- Mavi HS & Tupper Graeme J. 2004. Agrometeorology: Principles and Applications of Climate Studies in Agriculture. The Haworth Press.
- Raj Singh, Diwan Singh & Rao VUM. 2006. Manual on Applied Agricultural Climatology. Dept of Agril Meteorology, CCS HAU Hisar, India.
- Subramaniam VP. 1977. Incidence and Spread of Continental Drought. WMO/IMD Report No. 2, WMO, Geneva, Switzerland.
- Thompson R. 1997. Applied Climatology: Principles and Practice. Routledge.
- Walter J Saucier 2003. Principles of Meteorological Analysis. Dover Phoenix Eds.

AGM 601 : CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT 2+1

Objective

To impart the theoretical and practical knowledge of climate change and their sources.

Theory

UNIT I

Climate change and global warming: definitions of terms; causes of climate change and global warming; greenhouse gases, ozone depletion; past records, present trends, extreme weather events and future projections; astronomical predictions: lunar cycle, sunspot cycle, soil-lunar tides, Chandlers compensation, blocking highs.

UNIT II

Impacts of climate change on various systems: impacts resulting from projected changes on agriculture and food security; hydrology and water resources; terrestrial and freshwater ecosystems; coastal zones and marine ecosystems; human health; human settlements, energy, and industry; insurance and other financial services; climate change and crop diversification, loss of biodiversity, microbes and pest dynamics; climate change and storage, climate change and weed management.

UNIT III

Sensitivity, adaptation and vulnerability: system's sensitivity, adaptive capacity and vulnerability to climate change and extreme weather events; regional scenarios of climate change and variability.

UNIT IV

Mitigation strategies for sustainable development: international policies, protocols, treaties for reduction in greenhouse gases and carbon emissions; carbon sequestration; carbon credit; clean development mechanism (CDM) and land use, land use change and forestry mechanism, alternate energy sources etc.

UNIT V

Agricultural food security: reduction in carbon and GHG emission; fuel conservation and reduction in energy use, conservation tillage, biofuels for fossil fuels, reduction in machinery use etc; increasing carbon sinks; resource conservation technologies, mixed rotations of cover and green manure crops, minimization of summer fallow and no ground cover periods etc.

Practical

- Case studies on various climatic projections and consequences thereof in relation to agriculture
- Advance methodology of assessing the impact of climate change on crops

Suggested Readings

- Anonymous. Clean Development Mechanism: Building International Public-Private Partnership under Kyoto Protocol. UNEP, UNDP Publ.
- Anonymous. IPCC Assessment Reports on Climate Change (2001, 2007). WMO, UNEP Publ.
- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- Jepma CJ & Munasinghe M. 1998. Climate Change Policy: Facts, Issues and Analysis. Cambridge Univ. Press.
- Mintzer IM. 1992. Confronting Climate Change: Risks, Implications and Responses. Cambridge Univ. Press.

- Pretty J & Ball A. 2001. Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options. Univ. of Essex.
- Pretty JN. 1995. Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance. Earthscan.
- Salinger J, Sivkumar MVK & Motha RP. 2005. Increasing Climate Variability of Agriculture and Forestry. Springer.
- Sinha SK. 1998. Dictionary of Global Climate Change. Commonwealth Publ.

AGM 602 : WEATHER FORECASTING 2+1

Objective

To impart theoretical and practical knowledge of forecasting techniques used for weather prediction and preparation of agro-advisories.

Theory

UNIT I

Weather forecasting system: definition, scope and importance; types of forecasting: short, medium and long-range; study of synoptic charts with special reference to location of highs and lows, jet streams, synoptic features and weather anomalies and zones of thermal advection and interpretation of satellite pictures of clouds in visible and infra-red range; weather forecasting network.

UNIT II

Approaches for weather forecasts: methods of weather forecasts - synoptic, numerical prediction, statistical, analogue, persistence and climatological approach, nano-technological approach, Indigenous Technical Knowledge (ITK) base- signals from flora, fauna, insects, birds, animals behavior; various methods of verification of location-specific weather forecast.

UNIT III

Weather based advisories: interpretation of weather forecasts for soil moisture, farm operations, pest and disease development and epidemics, crops and livestock production; preparation of weather-based advisories and dissemination.

UNIT IV

Special forecasts: special forecasts for natural calamities such as drought, floods, high winds, cold (frost) and heat waves, hail storms, cyclones and protection measures against such hazards.

UNIT V

Modification of weather hazards: weather modification for agriculture; scientific advances in artificial rain making, hail suppression, dissipation of fog and stratus clouds, modification of severe storms and electric behavior of clouds.

Practical

- Exercise on weather forecasting for various applications
- Preparation of weather-based agro-advisories based on weather forecast using various approaches and synoptic charts.

Suggested Readings

- Alan Watts 2005. Instant Weather Forecasting. Water Craft Books.
- Ram Sastry AA. 1984. Weather and Weather Forecasting. Publication Division, GOI, New Delhi.
- Singh SV, Rathore LS & Trivedi HKN. 1999. A Guide for Agrometeorological Advisory Services. Department of Science & Technology, NCMRWF, New Delhi.
- Wegman & Depriest 1980. Statistical Analysis of Weather Modification Experiments. Amazon Book Co.

AGM 603 : AIR POLLUTION METEOROLOGY 2+1

Objective

To impart the theoretical and practical knowledge of air pollutants.

Theory

UNIT I

Introduction to air pollution- history, definition: clean air definition; natural versus polluted atmosphere; atmosphere before the industrial revolution.

UNIT II

Sources of air pollution; classification and properties of air pollutants;
emission sources, importance of anthropogenic sources; behaviour and fate of air pollutants; photochemical smog; pollutants and trace gases.

UNIT III

Meteorological factors in the dispersion of air pollutants; topographical, geographical and large scale meteorological factors attached air pollution; meteorological conditions and typicalplumeforms;airpollution forecasting – Gaussian diffusion models, Numerical dispersion models.

UNIT IV

Air quality standards; effect of air pollution on biological organisms; ozone layer depletion; air pollution control technologies; management of air pollution; principles of diffusion of particulate matter in the atmosphere; air pollution laws and standards.

UNIT V

Air pollution sampling and measurement: types of pollutant sampling and measurement, ambient air sampling, collection of gaseous air pollutants, collection of particulate pollutants, stock sampling; analysis of air pollutants - sulfur dioxide, nitrogen dioxide, carbon monoxide, oxidants and ozone, hydrocarbons, particulate matter.

UNIT VI

Scales of air pollution: local, urban, regional, continental and global.

Practical

- Measurement of different air pollutants
- Measurement of different air pollution gases
- Measurement of visibility
- Measurement of ozone and aerosol optical thickness (AOT)
- To study the temperature profile at different heights
- To study the stability of the atmosphere
- To determine height of partial flume through chimani
- To study the effect of temperature on vegetables, orchards and agricultural crops

Suggested Readings

- Arya SP. 1998. Air Pollution Meteorology and Dispersion. Oxford Univ. Press.
- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- Chhatwa GR. 1989. Environmental Air Pollution and its Control. Anmol Publ.
- Mishra PC. 1990. Fundamentals of Air and Water Pollution. Ashish Publ.
- Mudd J Brian & Kozlowski TT. (Ed.). 1975. Responses of Plants to Air Pollution. Academic Press.
- Pickett EE. 1987. Atmopheric Pollution. Hemisphere Publ. Corp.
- Sharma SH & Khan TI. 2004. Ozone Depletion and Environmental Impacts. Pointer Publ.
- Weber E. 1982. Air Pollution Assessment Methodology and Modeling. Plenum Press.
- Yunus M & Iqbal M. (Eds.). 1996. Plant Response to Air Pollution. John Wiley & Sons.

AGM 604 : WEATHER, CLIMATE AND LIVESTOCK 2+1

Objective

To impart the theoretical and practical knowledge of weather, climate for livestock management.

Theory

UNIT I

Thermal balance in animals; energy exchange processes at the skin of the animals and the need for the maintenance of thermal balance in the animals.

UNIT II

Effects of weather on animal production, loss of water from the body, growth rate and body weight, reproduction, grazing habit, food intake, milk production, sun burns and photosensitive disorders.

UNIT III

Meteorological conditions prevailing in glass-house, green house, animal shed, poultry house and grain storage barns; heating, cooling and ventilation of these structures as governed by meteorological factors.

UNIT IV

Weather and animal diseases and parasites; diseases of poultry and its relation with weather and thermal comfort.

UNIT V

Management of livestock to reduce greenhouse gas emission.

Practical

- Measurement of temperature, humidity, net radiation
- Calculation of animal comfort zone index
- Radiation of animal farm house and body
- Estimation of enegy fluxes on body
- Measurements of CO_2 and methane in animal farm house

Suggested Readings

- Kaiser HM & Drennen TE. (Eds). 1993. Agricultural Dimensions of Global Climate Change. St. Lucie Press, Florida.
- Monteith L & Unsworth M. 2007. Principles of Environmental Physics. 2nd Ed. Academic Press.
- Takahashi J, Young BA, Soliva CR & Kreuzer M. 2002. Greenhouse Gases and Animal Agriculture. Proc. 1st International Conference on Greenhouse Gases and Animal Agriculture.
- Tromp SW. 1980. Biometeorology. The Impact of the Weather and Climate on Humans & their Environment. (Animals & Plants). Heyden & Son Ltd.

AGM 605 : ANALYTICAL TOOLS AND METHODS FOR AGRO-METEOROLOGY 2+1

Objective

To impart the theoretical and practical knowledge of new tools for analysis of agro-climatic features.

Theory

UNIT I

Review of agro-climatic methods; characterization of agroclimatic elements; sampling of atmosphere; temporal and spatial considerations; micro-meso-macro climates.

UNIT II

Network spacing; spatial and temporal methods; GIS fundamentals and applications; numerical characterization of climatic features; crop response to climate, time lags, time and distance constants, hysteresis effects.

UNIT III

Influence of climate on stress-response relations; thermal time approach in agroclimatology-heat and radiation use efficiency in crop plants; applications to insect-pest development and prediction; comfort indices for human and animals; impact of natural and induced variability and change of climate on crop production.

UNIT IV

Instrumentation and sampling problems; design of agro-meteorological experiments.

UNIT V

Basic knowledge of application of computers in agriculture; theories of computer language BASIC, FORTRAN, C, C++ and Visual basic.

UNIT VI

Empirical and statistical crop weather models and their application with examples; incorporating weather, soil, plants and other environment- related parameters as subroutine and remote sensing inputs in models; growth and yield prediction models; crop simulation

models; forecasting models for insects and diseases.

Practical

- Calculation of continentality factors.
- Climatic indices and climogram.
- Agrometeorological indices: Degree-days, photothermal units, heliothermal units, phenothermal index.
- Heat and radiation use efficiency and other indices of crops.
- Crop growth rates.
- Analysis of thermogram, hygrogram, hyetogram, sunshine cards etc. stream lines and wind roses and statistical analysis of climatic data.
- Working with statistical models: crop yield forecasting, crop weather relationship and insect & disease forecasting models.
- Working with crop simulation models
- Small programme writing in computer languages like BASIC, FORTRAN, C, C++ and Visual basic.
- Geographical Information System.

Suggested Readings

❖ Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.

❖ Cooper M. 2006. The Spirit of C. An Introduction to Modern Programming. Jaico Publ.

❖ Malczewski J. 1999. GIS & Multicriteria Decision Analysis. John Wiley & Sons.

AGM 606 : STRATEGIC USE OF CLIMATIC INFORMATION 2+1

Objective

To impart the theoretical and practical knowledge of climatic hazards and their mitigations.

Theory

UNIT I

Increasing awareness on potential climate hazards and mitigations: history of climate-related disasters (hazards and vulnerabilities) suffered in the concerned continent/region/country/sub-region and their documented or remembered impacts; hazards and their relation to agricultural production risks (intra- and inter-annual); efforts made in mitigating impacts of (future) disasters (prevention); trends discernable in occurrence and character of disasters, if any.

UNIT II

Selection of appropriate land use and cropping patterns: types and drivers of agricultural land use and cropping patterns; history of present land use and cropping patterns in the continent/region/country/sub-region concerned as related to environmental issues; successes and difficulties experienced by farmers with present land use and cropping patterns; outlook for present land use and cropping patterns and possible alternatives from an environmental point of view.

UNIT III

Recent trends in land use and cropping patterns; adoption of preparedness strategies - priority settings for preparedness strategies in agricultural production; preparedness for meteorological disasters in development planning; permanent adaptation strategies that reduce the vulnerabilities to hazards; preparedness as a coping strategy.

UNIT IV

Making more efficient use of agricultural inputs: agro-meteorological aspects of agricultural production inputs and their history; determination of input efficiencies; other factors determining inputs and input efficiency; actual use of inputs in main land use and cropping patterns of the region.

UNIT V

Selection of livestock management: history of livestock management patterns in the continent/region/country/sub-region concerned as related to environmental issues; successes and difficulties experienced by farmers with present livestock management strategies; outlook for present livestock management strategies and possible alternatives from an environmental point of view; recent trends in livestock management strategies.

UNIT VI

Adoption of microclimate modification techniques: review of microclimate management and manipulation methods; history of microclimate modification techniques practised in the continent/country/sub-region concerned; possible improvements in adoption of microclimate modification techniques, given increasing climate variability and climate change; local trends in adoption of such techniques.

UNIT VII

Protection measures against extreme climate: history of protection measures against extreme climate in the continent/region/country/sub- region concerned; successes and difficulties experienced by farmers with present protection measures; outlook for present protection measures and possible alternatives; trends in protection methods against extreme climate.

Practical

- Outlook for present land use and cropping patterns and possible alternatives from environmental point of view
- Recent trends in land use and cropping patterns
- Agro-meteorological services to increase farmers design abilities of land use and cropping patterns
- Systematic and standardized data collection on protection measures against extreme climate

Suggested Readings

- ❖ Anonymous. Clean Development Mechanism: Building International Public-Private Partnership under Kyoto Protocol. UNEP, UNDP Publ.
- ❖ Anonymous. IPCC Assesment Reports on Climate Change Policy: Facts, Issues and Anlysis. Cambridge Univ. Press.
- ❖ Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- ❖ Pretty J & Ball A. 2001. Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options. Univ. of Essex.
- ❖ Pretty JN. 1995. Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance. Earthscan.
- ❖ Sinha SK. 1998. Dictionary of Global Climate Change. Commonwealth Publ.

AGM 607 : MATHEMATICS IN AGRICULTURE AND BIOLOGY 2+1

Objective

To impart the theoretical and practical knowledge of mathematical concept in bioscience.

Theory

UNIT I

Functions: function of a single real variable; single-valued and many- valued functions; linear functions; power functions; polynomial functions; trigonometric, exponential and logarithmic functions; functions of several real variables.

UNIT II

Differentiation: derivative of the function of a single variable; derivatives of the functions of several variables-partial derivatives; maxima and minima; applications.

UNIT III

Integration: integrals of functions with respect to their independent variables; indefinite, definite and infinite integrals, applications.

UNIT IV

Ordinary differential equations: classification; solution of linear differential equations; applications; partial differential equations - classification, applications.

UNIT V

Vectors: rules of the game with the vectors; applications; matrices and determinants: characterization; rules of the game with matrices and determinants; systems of linear algebraic equations and their solutions; characteristic roots of matrices; applications.

UNIT VI

Methods of analysis: averaging and scaling methods, numerical analysis; finite element method, Monte Carlo analysis, spatial variability, stochastic methods, Fourier Analysis, perturbation; iterative and optimal techniques; applications.

UNIT VII

Probability: probability and probability distributions; applications.

Practical

- Use of simple log and semi-log graph papers
- Use of logarithms and logarithmic tables
- Plotting linear and log graph
- Trigonometric functions and relations
- Data representation as pie, bar and histograms
- Statistical data analysis-averages, standard deviations, simple correlation coefficient

Suggested Readings

- Arya JC & Lardner RW.1979. Mathematics for Biological Sciences. Prentice Hall.
- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- Crank J, Martin HG & Melluish DM. 1980. Mathematics for Biological Sciences, Oxford Univ. Press.
- Eason G, Coles C, Wand Gettinby G. 1980. Mathematics and Statistics for Biosciences, Ellis Harwood Ltd.
- Francis 1983. Theory and Problems of Numerical Analysis. McGraw Hill.
- Hann CT. 1995. Statistical Methods in Hydrology. East-West Press.
- Panse VG & Sukhatme PV. 1983. Statistical Methods for Agricultural Workers. ICAR.
- Ramachery SKVS, Bhujanga Rao M & Bhandari S. 2000. Engineering Mathematics. IBS Publ.
- Ray M & Sharma HS. 1970. Mathematical Statistics. Ram Prasad & Sons.
- Vashistha AR. 1991. Modern Algebra. Krishna Prakashan Mandir.

AGM 608 : DATABASE MANAGEMENT AND COMMERCIALIZATION OF AGROMETEOROLOGICAL DATA IN E-SERVICES 1+2

Objective

To impart knowledge on management of agromet data and train the students in commercialization of agrometeorological data through e- services.

Theory

UNIT I

Data and information; types of data; climate, soil and crop data; Importance of database management; data requirements; data collection and recording (Automatic and manual).

UNIT II

Data structure/format; quality control of data; techniques of climatic data generation; missing data; introduction to different software for database management.

UNIT III

Processing and analysis of data and data products; value addition of data and data products; data users, public, commercial, academic or research.

UNIT IV

Availability, accessibility and security of data; evaluating the cost of data; e-management of data.

Practical

- Types of instruments and data recording
- AWS data retrieval, storage and transfer
- Exposure to different software for Agromet data analysis; exposure to Statistical software
- Temporal and spatial analysis of data; exposure to GIS
- Value addition to data
- Introduction to internet protocols
- Uploading and downloading data, password and security of data

- E-management of data

Suggested Readings

- Ghadekar R. 2002. Practical Meteorology – Data Acquisition Techniques, Instruments and Methods. 4th Ed. Agromet Publ.
- IMD/ WHO. 1988. Users Requirements for Agrometeorological Services. IMD.
- Miles MB & Huberman AM. 1994. Qualitative Data Analysis. Sage Publ.
- Panse VG & Sukhatme PV. 1983. Statistical Methods for Agricultural Workers, ICAR.
- Potter GB. 1994. Data Processing: An Introduction. Business Publ.
- Ramakrishnan R. & Gehrke J. 2003. Database Management System. McGraw-Hill.

AGRONOMY

AGRON 501 : MODERN CONCEPTS IN CROP PRODUCTION 3+0

Objective

To teach the basic concepts of soil management and crop production.

Theory

UNIT I

Crop growth analysis in relation to environment; agro-ecological zones of India and Gujarat.

UNIT II

Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

UNIT III

Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.

UNIT IV

Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress.

UNIT V

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture.

Suggested Readings

- Balasubramaniyan P & Palaniappan SP. 2001. Principles and Practices of Agronomy. Agrobios.
- Fageria NK. 1992. Maximizing Crop Yields. Marcel Dekker.
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- Paroda R.S. 2003. Sustaining our Food Security. Konark Publ.
- Reddy SR. 2000. Principles of Crop Production. Kalyani Publ.
- Sankaran S & Mudaliar TVS. 1997. Principles of Agronomy. The Bangalore Printing & Publ.
- Singh SS. 2006. Principles and Practices of Agronomy. Kalyani.

AGRON 502 : SOIL FERTILITY AND NUTRIENT MANAGEMENT 2+1

Objective

To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory

UNIT I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

UNIT II

Criteria of essentiality of nutrients; Essential plant nutrients - their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

UNIT III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management.

UNIT IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency, fertilizer mixtures and grades; agronomic, chemical and physiological methods of increasing fertilizer use efficiency; nutrient interactions.

UNIT V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic manures; economics of fertilizer use; integrated nutrient management; use of vermicompost and residue wastes in crops.

Practical

- Determination of soil pH, ECe, organic C, total N, available N, P, K and S in soils
- Determination of N, P, K and S content in plants.
- Interpretation of interaction effects and computation of economic and yield optima.

Suggested Readings

- ❖ Brady NC & Weil R.R 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- ❖ Fageria NK, Baligar VC & Jones CA. 1991. Growth and Mineral Nutrition of Field Crops Marcel Dekker.
- ❖ Havlin JL, Beaton JD, Tisdale SL & Nelson WL. 2006. Soil Fertility and Fertilizers. 7th Ed. Prentice Hall.
- ❖ Prasad R & Power JF. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press.
- ❖ Yawalkar KS, Agrawal JP & Bokde S. 2000. Manures and Fertilizers. Agri-Horti Publ.

AGRON 503 : PRINCIPLES AND PRACTICES OF WEED MANAGEMENT 2+1

Objective

To familiarize the students about the weeds, herbicides and methods of weed control.

Theory

UNIT I

Weed biology and ecology, crop-weed competition including allelopathy; principles and methods of weed control and classification.

UNIT II

Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

UNIT III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures; herbicide resistance and management; weed control through bio-herbicides, myco-herbicides and allelochemicals; Degradation of herbicides in soil and plants; herbicide resistance in weeds and crops; herbicide rotation.

UNIT IV

Weed management in major crops and cropping systems; parasitic weeds; weed shifts in cropping systems; aquatic and perennial weed control.

UNIT V

Integrated weed management; cost: benefit analysis of weed management.

Practical

- Identification of important weeds of different crops
- Preparation of a weed herbarium
- Weed survey in crops and cropping systems
- Crop-weed competition studies
- Preparation of spray solutions of herbicides for high and low-volume sprayers
- Use of various types of spray pumps and nozzles and calculation of swath width
- Economics of weed control
- Calculation of weed indices
- Bioassay of herbicide
- Calculation of herbicidal requirement

Suggested Readings

- ❖ Aldrich RJ & Kramer RJ. 1997. Principles in Weed Management. Panima Publ.
- ❖ Ashton FM & Crafts AS. 1981. Mode of Action of Herbicides. 2nd Ed. Wiley Inter-Science.
- ❖ Gupta OP. 2007. Weed Management – Principles and Practices. Agrobios.
- ❖ Mandal RC. 1990. Weed, Weedicides and Weed Control - Principles and Practices. Agro-Botanical Publ.
- ❖ Rao VS. 2000. Principles of Weed Science. Oxford & IBH. Subramanian S, Ali AM & Kumar RJ. 1997. All About Weed Control. Kalyani.
- ❖ Zimdahl RL. 1999. Fundamentals of Weed Science. 2nd Ed. Academic Press.

AGRON 504 : PRINCIPLES AND PRACTICES OF WATER MANAGEMENT 2+1

Objective

To teach the principles of water management and practices to enhance the water productivity.

Theory

UNIT I

Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states.

UNIT II

Soil water movement in soil and plants; transpiration; soil-water-plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition.

UNIT III

Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation; microirrigation system; fertigation; management of water in controlled environments and polyhouses.

UNIT IV

Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; water use efficiency.

UNIT V

Excess of soil water and plant growth; water management in problem soils; drainage requirement of crops and methods of field drainage, their layout and spacing.

Practical

- Measurement of soil water potential by using tensiometer, and pressure plate and membrane apparatus
- Soil-moisture characteristics curves
- Water flow measurements using different devices
- Determination of irrigation requirements
- Calculation of irrigation efficiency
- Determination of infiltration rate
- Determination of saturated/unsaturated hydraulic conductivity

Suggested Readings

- Lenka D. 1999. Irrigation and Drainage. Kalyani
- Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.
- Paliwal KV. 1972. Irrigation with Saline Water. IARI Monograph, New Delhi.
- Panda SC. 2003. Principles and Practices of Water Management. Agrobios.
- Prihar SS & Sandhu BS. 1987. Irrigation of Food Crops - Principles and Practices. ICAR.
- Misra RD and Ahmed, M. 1990 A Practical Manual on irrigation. Oxford & IBH Publishing co. Pvt. Ltd., New delhi.
- Reddy SR. 2000. Principles of Crop Production. Kalyani.
- Reddi GHS and Reddy TY 2002. Efficient use of irrigation water. Kalyani.
- Singh Pratap & Maliwal PL. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ.

AGRON 505 : AGROMETEOROLOGY AND CROP WEATHER FORECASTING 2+1

Objective

To impart knowledge about agro-meteorology and crop weather forecasting to meet the challenges of aberrant weather conditions.

Theory

UNIT I

Agro meteorology - aim, scope and development in relation to crop environment; composition of atmosphere, distribution of atmospheric pressure and wind.

UNIT II

Characteristics of solar radiation; energy balance of atmosphere system; radiation distribution in plant canopies, radiation utilization by field crops; photosynthesis and efficiency of radiation utilization by field crops; energy budget of plant canopies; environmental temperature: soil, air and canopy temperature.

UNIT III

Temperature profile in air, soil, crop canopies; soil and air temperature effects on plant processes; environmental moisture and evaporation: measures of atmospheric temperature and relative humidity vapor pressure and their relationships; evapo-transpiration and meteorological factors determining evapotranspiration.

UNIT IV

Modification of plant environment: artificial rain making, heat transfer, controlling heat load, heat trapping and shading; protection from cold, sensible and latent heat flux, controlling soil moisture; monsoon and their origin, characteristics of monsoon; onset, progress and withdrawal of monsoon; weather hazards, drought monitoring and planning for mitigation.

UNIT V

Weather forecasting in India – short, medium and long range; aerospace science and weather forecasting; benefits of weather services to agriculture, remote sensing; application in agriculture and its present status in India; atmospheric pollution and its effect on climate and crop production; climate change and its impact on agriculture.

Practical

- Visit to agro-meteorological observatory and to record sun-shine hours, wind velocity, wind direction, relative humidity, soil and air temperature, evaporation, precipitation and atmospheric pressure
- Measurement of solar radiation outside and within plant canopy
- Measurement/estimation of evapo-transpiration by various methods
- Measurement/estimation of soil water balance
- Rainfall variability analysis
- Determination of heat-unit requirement for different crops
- Measurement of crop canopy temperature
- Measurement of soil temperatures at different depths
- Remote sensing and familiarization with agro-advisory service bulletins
- Study of synoptic charts and weather reports, working principle of automatic weather station

- Visit to solar observatory

Suggested Readings

- Chang Jan Hu 1968. Climate and Agriculture on Ecological Survey. Aldine Publ.
- Critchfield HJ.1995. General Climatology. Prentice Hall of India.
- Das PK.1968. The Monsoons. National Book Trust Publ.
- Lal DS.1998. Climatology. Sharda Pustak Bhawan.
- Lenka D.1998. Climate, Weather and Crops in India. Kalyani.
- Mavi H.S.1994. Introduction to Agro-meteorology. Oxford & IBH.
- Mavi HS & Tupper GJ. 2004. Agrometeorology: Principles and Application of Climate Studies in Agriculture. Haworth Press.
- Menon PA.1991. Our Weather. National Book Trust Publ.
- Sahu DD. Agrometeorology and Remote Sensing: Principles and Practices. Agrobios.
- Variraju R & Krishnamurty 1995. Practical Manual on Agricultural Meteorology. Kalyani.
- Varshneya MC & Balakrishana Pillai P. 2003. Textbook of Agricultural Meteorology. ICAR.

AGRON 506 : AGRONOMY OF MAJOR CEREALS AND PULSES 2+1

Objective

To teach the crop husbandry of cereals and pulse crops.

Theory

Origin and history, botanical description, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of

UNIT I

Rabi cereals: Wheat

UNIT II

Kharif cereals: Rice, Sorghum, Maize and Pearmillet

UNIT III

Rabi pulses: Chickpea, Pea and Indian bean

UNIT IV

Kharif pulses: Pigeon pea, Green gram, Black gram, Cowpea and kidney bean.

Practical

- Phenological observation at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Working out growth indices (LAI, CGR, RGR, NAR, LAD), aggressiveness, relative crowding coefficient, monetary yield advantage and ATER of prominent intercropping systems of different crops
- Estimation of protein content in pulses
- Judging of physiological maturity in different crops
- Determination of cost of cultivation of different crops
- Working out harvest index of various crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

Suggested Readings

- Das NR. 2007. Introduction to Crops of India. Scientific Publ.
- Hunsigi G & Krishna KR. 1998. Science of Field Crop Production. Oxford & IBH.
- Jeswani LM & Baldev B. 1997. Advances in Pulse Production Technology. ICAR.
- Khare D & Bhale MS. 2000. Seed Technology. Scientific Publ.
- Kumar Ranjeet & Singh NP. 2003. Maize Production in India: Golden Grain in Transition. IARI, New Delhi.
- Pal M, Deka J & Rai RK. 1996. Fundamentals of Cereal Crop Production. Tata McGraw Hill.

- Panda, SC. 2006. Crop management and integrated farming. Agrobios (India)
- Prasad, Rajendra. 2002. Text Book of Field Crop Production. ICAR.
- Singh C, Singh P & Singh R. 2003. Modern Techniques of Raising Field Crops. Oxford & IBH.
- Singh, SS. 1998. Crop Management. Kalyani.
- Yadav DS. 1992. Pulse Crops. Kalyani.

AGRON 507 : AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS 2+1

Objective

To teach the crop husbandry of oilseed, fiber and sugar crops.

Theory

Origin and history, botanical description, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing of the produce for maximum production of :

UNIT I

Rabi oilseeds – Rapeseed and mustard, linseed, niger and safflower

UNIT II

Kharif oilseeds - Groundnut, sesame, castor, sunflower and soybean

UNIT III

Fiber crops - Cotton, Jute and Sunhemp

UNIT IV

Sugar crops – Sugar-beet and sugarcane.

Practical

- Phenological observation at different growth stages of crops
- Methods of sowing, tying and propping of sugarcane
- Seed treatment to various crops.
- Working out growth indices (LAI, CGR, RGR, NAR, LAD) aggressivity, relative crowding coefficient, monetary yield advantage and ATER of prominent intercropping systems
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Determination of oil content in oilseeds and computation of oil yield
- Estimation of quality of fibre of different fibre crops
- Study of seed production techniques in various crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

Suggested Readings

- Das NR. 2007. Introduction to Crops of India. Scientific Publ.
- Das PC. 1997. Oilseed Crops of India. Kalyani.
- Lakshmikantam N. 1983. Technology in Sugarcane Growing. 2nd Ed. Oxford & IBH.
- Prasad, Rajendra. 2002. Text Book of Field Crop Production. ICAR.
- Singh C, Singh P & Singh R. 2003. Modern Techniques of Raising Field Crops. Oxford & IBH.
- Singh SS. 1998. Crop Management. Kalyani.

AGRON 508 : AGRONOMY OF MEDICINAL, AROMATIC AND UNDER-UTILIZED CROPS 2+1

Objective

To acquaint students about different medicinal, aromatic and underutilized field crops, their package of practices and processing.

Theory

UNIT I

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and uses.

UNIT II

Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Isabgol, Rauwolfia, Poppy, *Aloe vera*, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, *Nux vomica*, Rosadle , Senna, Guggal, Aswagandha, Shankhpuspi, Cress and Dodi).

UNIT III

Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium and Khush grass).

UNIT IV

Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, Sesbania, French bean, Fenugreek, Grain Amaranth, Karingdo and Tobacco).

Practical

- Identification of crops based on morphological and seed characteristics
- Quality characters in medicinal and aromatic plants
- Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants

Suggested Readings

- Chadha KL & Gupta R. 1995. Advances in Horticulture. Vol. II. Medicinal and Aromatic Plants. Malhotra Publ.
- Das NR. 2007. Introduction to Crops of India. Scientific Publ.
- Handa SS. 1984. Cultivation and Utilization of Medicinal Plants. RRL, CSIR, Jammu.
- Hussain A. 1984. Essential Oil Plants and their Cultivation. CIMAP, Lucknow.
- Hussain A. 1993. Medicinal Plants and their Cultivation. CIMAP, Lucknow.
- ICAR 2006. Hand Book of Agriculture. ICAR, New Delhi.
- Kumar N, Khader Md. Abdul, Rangaswami JBM & Irulappan 1997. Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants. Oxford & IBH.
- Prajapati ND, Purohit SS, Sharma AK & Kumar T. 2003. A Hand Book of Medicinal Plants: A Complete Source Book. Agrobios.
- Sharma R. 2004. Agro-Techniques of Medicinal Plants. Daya Publ. House.

AGRON 509 : AGRONOMY OF FODDER AND FORAGE CROPS 2+1

Objective

To teach the crop husbandry of different forage and fodder crops along with their processing.

Theory

UNIT I

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like maize, sorghum, *bajra*, *guar*, cowpea, oats, berseem, *chicory*, Rajka bajri, lucerne and sunflower

UNIT II

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasses like, napier grass, *Panicum, Cenchrus and* marvel grass.

UNIT III

Year-round fodder production and management, preservation and utilization of forage and pasture crops.

UNIT IV

Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder.

UNIT V

Grazing and grassland management

UNIT VI

Economics of forage crops and seed production techniques.

Practical

- Practical training of farm operations in raising fodder crops;
- Canopy measurement, yield and quality estimation, viz. dry matter, crude protein, crude fibre, NDF, ADF and cellulose of various fodder and forage crops
- Anti-quality components like HCN in sorghum and such factors in other crops
- Hay and silage making and economics of their preparation

Suggested Readings

- ❖ Chatterjee BN. 1989. Forage Crop Production - Principles and Practices. Oxford & IBH.
- ❖ Das NR. 2007. Introduction to Crops of India. Scientific Publ.
- ❖ Narayanan TR & Dabadghao PM. 1972. Forage Crops of India. ICAR.
- ❖ Singh P & Srivastava AK. 1990. Forage Production Technology. IGFRI, Jhansi.
- ❖ Singh C, Singh P & Singh R. 2003. Modern Techniques of Raising Field Crops. Oxford & IBH.
- ❖ Tejwani KG. 1994. Agroforestry in India. Oxford & IBH.

AGRON 510 : AGROSTOLOGY AND AGRO-FORESTRY 2+1

Objective

To teach crop husbandry of different forage, fodder and agro forestry crops/trees along with their processing.

Theory

UNIT I

Agrostology: definition and importance; principles of grassland ecology: grassland ecology, community, climax, dominant species, succession, biotype, ecological status of grasslands in India, grass cover of India; problems and management of grasslands.

UNIT II

Importance, classification, scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses.

UNIT III

Agroforestry: definition and importance; agroforestory systems, agrisilviculture, silvipasture, agrisilvipasture, agrihorticulture, aquasilviculture, alley cropping and energy plantation.

UNIT IV

Crop production technology in agro-forestry and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation and manuring in agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in agro-forestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

Practical

- Identification of seeds and plants of common grasses, legumes and trees of economic
- importance with reference to agro-forestry
- Seed treatment for better germination
- Methods of propagation/planting of grasses and trees in silvipastoral system
- Fertilizer application in strip and silvipastroal systems
- After-care of plantation
- Estimation of protein content in loppings of important fodder trees

- Estimation of calorie value of wood of important fuel trees
- Estimation of total biomass and fuel wood
- Economics of agro-forestry
- Visit to important agro-forestry/grass land research stations

Suggested Readings

- ❖ Chatterjee BN & Das PK. 1989. Forage Crop Production. Principles and Practices.Oxford & IBH.
- ❖ Dabadghao PM & Shankaranarayan KA. 1973. The Grass Cover in India. ICAR.
- ❖ Dwivedi AP. 1992. Agroforestry- Principles and Practices. Oxford & IBH.
- ❖ Indian Society of Agronomy. 1989. Agroforestry System in India. Research and Development, New Delhi.
- ❖ Narayan TR & Dabadghao PM. 1972. Forage Crop of India. ICAR, New Delhi.
- ❖ Pathak PS & Roy MM. 1994. Agroforestry System for Degraded Lands. Oxford & IBH.
- ❖ Sen NL, Dadheech RC, Dashora LK & Rawat TS. 2004. Manual of Agroforestry and Social Forestry. Agrotech Publ.
- ❖ Shah SA.1988. Forestry for People. ICAR.
- ❖ Singh Panjab, Pathak PS & Roy MM.1994. Agroforestry System forSustainable Use. Oxford & IBH.
- ❖ Singh SP. 1994. Handbook of Agroforestry. Agrotech Publ.
- ❖ Solanki KR. 2000. Multipurpose Tree Species: Research, Retrospect and Prospects. Agrobios.
- ❖ Tejwani KG.1994. Agroforestry in India. Oxford & IBH.

AGRON 511 : CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE 2+0

Objective

To acquaint the students about prevailing cropping systems in the country and practices to improve their productivity.

Theory

UNIT I

Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

UNIT II

Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping, mechanism of yield advantage in intercropping systems.

UNIT III

Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; research need on sustainable agriculture.

UNIT IV

Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system.

UNIT V

Plant ideotypes for drylands; plant growth regulators and their role in sustainability.

Suggested Readings

- ❖ Palaniappan SP & Sivaraman K. 1996. Cropping Systems in the Tropics; Principles and Management. New Age.
- ❖ Panda SC. 2003. Cropping and Farming Systems. Agrobios.
- ❖ Reddy SR. 2000. Principles of Crop Production. Kalyani.
- ❖ Sankaran S & Mudaliar TVS. 1997. Principles of Agronomy. The Bangalore Printing & Publ. Co.
- ❖ Singh SS. 2006. Principles and Practices of Agronomy. Kalyani.

❖ Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1997. Soil Fertility and Fertilizers. Prentice Hall.

AGRON 512 : DRYLAND AGRICULTURE AND WATERSHED MANAGEMENT 2+1

Objective

To teach the basic concepts and practices of dry land farming and soil moisture conservation.

Theory

UNIT I

Definition, concept and characteristics of dry land agriculture;significance and dimensions of dry land agriculture in India.

UNIT II

Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

UNIT III

Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

UNIT IV

Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; soil and crop management techniques, seeding and efficient fertilizer use.

UNIT V

Concept of watershed resource management, objectives, problems, approach and components.

Practical

- Seed treatment, seed germination and crop establishment in relation to soil moisture contents
- Estimation of moisture index and aridity index
- Spray of anti-transpirants and their effect on crops
- Collection and interpretation of data for water balance equations
- Water use efficiency
- Visit to dryland research stations and watershed projects

Suggested Readings

❖ Das NR. 2007. Tillage and Crop Production. Scientific Publishers.
❖ Dhopte AM. 2002. Agrotechnology for Dryland Farming. Scientific Publ.
❖ Dhruv Narayan VV. 2002. Soil and Water Conservation Research in India. ICAR.
❖ Gupta US. (Ed.). 1995. Production and Improvements of Crops for Drylands. Oxford & IBH.
❖ Katyal JC & Farrington J. 1995. Research for Rainfed Farming. CRIDA.
❖ Rao SC & Ryan J. 2007. Challenges and Strategies of Dryland Agriculture. Scientific Publishers.
❖ Singh P & Maliwal PL. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publishing Company.
❖ Singh RP. 1988. Improved Agronomic Practices for Dryland Crops. CRIDA.
❖ Singh RP. 2005. Sustainable Development of Dryland Agriculture in India. Scientific Publ.
❖ Singh SD. 1998. Arid Land Irrigation and Ecological Management. Scientific Publishers.
❖ Venkateshwarlu J. 2004. Rainfed Agriculture in India. Research and Development Scenario. ICAR.

AGRON 513 : PRINCIPLES AND PRACTICES OF ORGANIC FARMING 2+1

Objective

To study the principles and practices of organic farming for sustainable crop production.

Theory

UNIT I

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; land and water management - land use,
minimum tillage; shelter zones, hedges, pasture management, agro-forestry.

UNIT II

Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures, biofertilizers, biodynamic and integrated bio nutrient management.

UNIT III

Farming systems, crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

UNIT IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, biopesticides.

UNIT V

Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures.

Practical

- Aerobic and anaerobic methods of making compost
- Making of vermicompost and vermiwash
- Identification and nursery raising of important agro-forestry tress and tress for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with *Rhizobium* cultures, use of *Azotobacter*, *Azospirillum*, and PSB cultures in field
- Visit to an organic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

Suggested Readings

- Ananthakrishnan TN. (Ed.). 1992. Emerging Trends in Biological Controlof Phytophagous Insects. Oxford & IBH.
- Gaur AC. 1982. A Manual of Rural Composting, FAO/UNDP Regional Project Document, FAO.
- Lampin N. 1990. Organic Farming. Press Books, Ipswitch, UK.
- Palaniappan SP & Anandurai K. 1999. Organic Farming – Theory and Practice. Scientific Publ.
- Rao BV Venkata. 1995. Small Farmer Focused Integrated RuralDevelopment: Socio-economic Environment and Legal Perspective: Publ.3, Parisaraprajna Parishtana, Bangalore.
- Reddy MV. (Ed.). 1995. Soil Organisms and Litter Decomposition in theTropics. Oxford & IBH.
- Sharma A. 2002. Hand Book of Organic Farming. Agrobios.
- Singh SP. (Ed.) 1994. Technology for Production of Natural Enemies.PDBC, Bangalore.
- Subba Rao NS. 2002. Soil Microbiology. Oxford & IBH.
- Trivedi RN.1993. A Text Book of Environmental Sciences, Anmol Publ.
- Veeresh GK, Shivashankar K & Suiglachar MA. 1997. Organic Farmingand Sustainable Agriculture. Association for Promotion of Organic Farming, Bangalore.
- WHO. 1990. Public Health Impact of Pesticides Used in Agriculture. WHO.
- Woolmer PL & Swift MJ. 1994. The Biological Management of Tropical Soil Fertility. TSBF & Wiley.

AGRON 601 : CURRENT TRENDS IN AGRONOMY 3+0

Objective

To acquaint the students about recent advances in agricultural production.

Theory

UNIT I

Agro-physiological basis of variation in yield, recent advances in soil plant- water relationship.

UNIT II

Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures.

UNIT III

Crop residue management in multiple cropping systems; latest developments in plant management, weed management, cropping systems, grassland management, agro-forestry, allelopathy.

UNIT IV

GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication and hybrid seed production

UNIT V

Concepts of system agriculture; holistic approach of farming systems, dry land agriculture, sustainable agriculture and research methodology in Agronomy.

UNIT VI

LEISA (low external input sustainable agriculture) and HEISA (high external input sustainable agriculture)

Suggested Readings

- Agarwal RL. 1995. Seed Technology. Oxford & IBH.
- Dahiya BS & Rai KN. 1997. Seed Technology. Kalyani.
- Govardhan V. 2000. Remote Sensing and Water Management in Command Areas: Agro ecological Prospectives. IBDC.
- ICAR. 2006. Hand Book of Agriculture. ICAR.
- Narasaiah ML. 2004. World Trade Organization and Agriculture. Sonali Publ.
- Palaniappan SP & Annadurai K. 2006. Organic Farming - Theory and Practice. Scientific Publ.
- Sen S & Ghosh N. 1999. Seed Science and Technology. Kalyani.
- Tarafdar JC, Tripathi KP & Mahesh Kumar 2007. Organic Agriculture. Scientific Publ.

AGRON 602 : CROP ECOLOGY 2+0

Objective

To acquaint the students about the agricultural systems, agro-ecological regions, and adaptation of crops to different agro-climatic conditions.

Theory

UNIT I

Concept of crop ecology, agricultural systems, ecology of cropping systems, principles of plant distribution and adaptation, crop and world food supply.

UNIT II

Ecosystem characteristics, types and functions, terrestrial ecology, flow of energy in ecosystem, ecosystem productivity, biomass, succession and climax concept.

UNIT III

Physiological response of crop plants to light, temperature, CO_2, moisture and solar radiation; influence of climate on photosynthesis and productivity of crops; effect of global climate change on crop production.

UNIT IV

Exploitation of solar energy in crops; vertical distribution of temperature; efficiency in crop production.

UNIT V

Competition in crop plants; environmental pollution, ecological basis of environmental management and environment manipulation through agronomic practices; improvement of unproductive lands through crop selection and management.

Suggested Readings

- Ambasht RS. 1986. A Text Book of Plant Ecology. 9th Ed. Students' Friends & Co.
- Chadha KL & Swaminathan MS. 2006. Environment and Agriculture. Malhotra Publ. House.
- Dwivedi P, Dwivedi SK & Kalita MC. 2007. Biodiversity and Environmental Biotechnology. Scientific Publ.
- Hemantarajan A. 2007. Environmental Physiology. Scientific Publ.
- Kumar HD. 1992. Modern Concepts of Ecology. 7th Ed. Vikas.Publ.
- Lenka D. 1998. Climate, Weather and Crops in India. Kalyani.
- Misra KC. 1989. Manual of Plant Ecology. 3rd Ed. Oxford & IBH.
- Pandey SN & Sinha BK. 1995. Plant Physiology. Vikas Publ.
- Sharma PD. 1998. Ecology and Environment. Rastogi Publ.
- Singh J & Dhillon SS. 1984. Agricultural Geography. Tata McGraw Hill.
- Taiz L & Zeiger E. 1992. Plant Physiology. Benjamin/Cummings Publ.

AGRON 603 : CROP PRODUCTION AND SYSTEM MODELING 2+1

Objective

To familiarize the students about systems approach and to simulate yields and growth of several crops under varied soil and weather conditions with different management practices and their optimization.

Theory

UNIT I

Systems classification; flow charts, modeling techniques and methods of integration, feedbacks and relational diagrams.

UNIT II

Elementary models for crop growth based on basic methods of classical growth analysis.

UNIT III

Crop modeling methods for crop-weather interaction, climate change and variability components.

UNIT IV

Potential production: leaf and canopy CO_2 assimilation, respiration, dry matter accumulation, crop phenology and dry matter distribution and development in different crops.

UNIT V

Production by moisture availability, potential evapotranspiration, water balance of the soil, and production with nutrient and moisture limitations.

Practical

- Simulation of elementary models for crop growth
- Simulation of potential production
- Simulation with limitations of water and nutrient management options
- Sensitivity analysis using different climatic years and crop management practices

Suggested Readings

- Gordan G. 1992. System Simulation. 2nd Ed. Prentice Hall. Kropff MJ & Vann Laar HH. (Ed.). 1993. Modeling Crop Weed Interactions. ISBN.
- Mathews RB, Kropff MJ, Bachelet D & Vaan Laar HH. (Eds.). 1993. Modeling the Impact of Climate Change on Rice Production in Asia. CABI.
- Penning de Vries FWT & Van Laar HH. (Eds.). 1982. Simulation of Plant Growth and Crop Production. Wageningen Centre for Agricultural Publications and Documentation, Netherlands.
- Ritchie JT & Hanks J. 1991. Modelling Plant and Soil Systems. American Society of Agronomy, Madison.

❖ Zeigler BP. 1976. Theory of Modeling and Simulation. John Wiley & Sons.

AGRON 604 : ADVANCES IN CROP GROWTH AND PRODUCTIVITY 2+1

Objective

To study the physiology of vegetative and reproductive growth in relation to productivity of different crops in various environments.

Theory

UNIT I

Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.

UNIT II

Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and Limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rain fed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

UNIT III

Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; heat unit concept of crop maturity: concept and types of heat units.

UNIT IV

Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotypes for wheat, rice, maize, etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.

Practical

- Field measurement of root-shoot relationship in crops at different growth stages
- Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth
- Computation of harvest index of various crops
- Assessment of crop yield on the basis of yield attributing characters
- Construction of crop growth curves based on growth analysis data
- Computation of competition functions, viz. LER, IER aggressively competition index etc inintercropping
- Senescence and abscission indices
- Analysis of productivity trend in un-irrigated areas
- Analysis of productivity trend in irrigated areas

Suggested Readings

❖ Chopra VL & Paroda RS. 1984. Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants. Oxford and IBH.
❖ Delvin RM & Vitham FH. 1986. Plant Physiology. CBS Publ.
❖ Evans LT. 1975. Crop Physiology. Cambridge Univ. Press.
❖ Evans LT. 1996. Crop Evolution, Adaptation and Yield. Cambridge Univ. Press.
❖ Gupta US. (Ed.). 1995. Production and Improvement of Crops for Drylands. Oxford & IBH.
❖ Gupta US. 1988. Progress in Crop Physiology. Oxford and IBH.
❖ Kramer PJ & Boyer JS. 1995. Water Relations of Plant and Soils.Academic Press.
❖ Mukherjee S & Ghosh AK. 1996. Plant Physiology. Tata McGraw Hill.
❖ Narwal SS, Politycka B & Goswami CL. 2007. Plant Physiology: Research Methods. Scientific Publishers.

AGRON 605 : IRRIGATION MANAGEMENT 2+1

Objective

To teach students about optimization of irrigation in different crops under variable agro climatic conditions.

Theory

UNIT I

Water resources of India, irrigation projects; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

UNIT II

Soil-plant-water relationships, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

UNIT III

Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

UNIT IV

Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

UNIT V

Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-Tran spirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

UNIT VI

Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation.

Practical

- Determination of water infiltration characteristics and water holding capacity of soil profiles
- Moisture extraction pattern of crops
- Consumptive use, water requirement of a given cropping pattern for optimum/variable productivity
- Crop planning at the farm and project level
- Agronomic evaluation of irrigation projects, case studies

Suggested Readings

- FAO. 1984. Irrigation Practice and Water Management. Oxford & IBH.
- Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.
- Mishra RR & Ahmad M. 1987. Manual on Irrigation and Agronomy. Oxford & IBH.
- Panda SC. 2003. Principles and Practices of Water Management. Agrobios.
- Reddy SR. 2000. Principles of Crop Production. Kalyani.
- Sankara Reddy GH & Yellamananda Reddy 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH.
- Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US. (Ed.). Production and Improvement of Crops for Drylands. Oxford & IBH.

AGRON 606 : ADVANCES IN WEED MANAGEMENT 2+0

Objective

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Theory

UNIT I

Crop-weed competition in different cropping situations; changes in weed flora, various causes and affects.

UNIT II

Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

UNIT III

Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, residue management of herbicides, adjuvants.

UNIT IV

Advances in herbicide application techniques; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides.

UNIT V

Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

UNIT VI

Relationship of herbicides with tillage, fertilizer and irrigation; bio herbicides, allelochemical herbicide bioassays.

Suggested Readings

- Aldrich RJ & Kramer R.J. 1997. Principles in Weed Management. Panama Publ.
- Ashton FM & Crafts AS. 1981. Mode of Action of Herbicides. 2nd Ed. Wiley-Inter Science.
- Gupta OP. 2000. Weed Management – Principles and Practices. Agrobios.
- Mandal RC. 1990. Weed, Weedicides and Weed Control - Principles and Practices. Agro-Botanical Publ.
- Rao VS. 2007. Principles of Weed Science. Oxford & IBH.
- Ross MA & Carola Lembi A. 1999. Applied Weed Science. 2nd Ed. Prentice Hall.
- Subramanian SAM & Kumar R.J. 1997. All About Weed Control. Kalyani.
- Zimdahl RL. 1999. Fundamentals of Weed Science. 2nd Ed. Academic Press.

AGRON 607 : INTEGRATED FARMING SYSTEMS FOR SUSTAINABLE AGRICULTURE 2+0

Objective

To apprise about different enterprises suitable for different agro climatic conditions for sustainable agriculture.

Theory

UNIT I

Farming systems: definition and importance; classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises.

UNIT II

Concept of sustainability in farming systems; efficient farming systems; natural resources - identification and management.

UNIT III

Production potential of different components of farming systems; interaction and mechanism of different production factors; stability in different systems through research; eco-physiological approaches to intercropping.

UNIT IV

Simulation models for intercropping; soil nutrient in intercropping; preparation of different farming system models; evaluation of different farming systems.

UNIT V

New concepts and approaches of farming systems and cropping systems and organic farming; case studies on different farming systems.

Suggested Readings

- Ananthakrishnan TN. (Ed.) 1992. Emerging Trends in Biological Control of Phytophagous Insects. Oxford & IBH.
- Balasubramanian P & Palaniappan SP 2006. Principles and Practices of Agronomy. Agrobios.

- Joshi M & Parbhakarasetty TK. 2005. Sustainability through Organic Farming. Kalyani.
- Lampin N. 1990. Organic Farming. Farming Press Books.
- Palaniappan SP & Anandurai K. 1999. Organic Farming - Theory andPractice. Scientific Publ.
- Panda SC. 2004. Cropping systems and Farming Systems. Agribios.
- Reddy MV. (Ed.). 1995. Soil Organisms and Litter Decomposition in theTropics. Oxford & IBH.
- Sharma AK. 2001. A Hand Book of Organic Farming. Agrobios.
- Singh SP. (Ed) 1994. Technology for Production of Natural Enemies. PDBC, Bangalore.
- Trivedi RN. 1993. A Text Book of Environmental Sciences. Anmol Publ.
- Veeresh GK, Shivashankar K & Suiglachar MA. 1997. Organic Farmingand Sustainable Agriculture. Association for Promotion of Organic Farming, Bangalore.
- Venkata Rao BV. 1995. Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective. Publ. 3. Parisaraprajna Parishtana, Bangalore.

AGRON 608 : SOIL CONSERVATION AND WATERSHED MANAGEMENT 2+1

Objective

To teach about different soil moisture conservation technologies for enhancing the agricultural productivity through holistic approach watershed management.

Theory

UNIT I

Soil erosion: definition, nature and extent of erosion; types of erosion, factors affecting erosion.

UNIT II

Soil conservation: definition, methods of soil conservation; agronomic measures - contour cultivation, strip cropping, cover crops; vegetative barriers; improved dry farming practices; mechanical measures - bunding, gully control, bench terracing; role of grasses and pastures in soil conservation; wind breaks and shelter belts.

UNIT III

Watershed management: definition, objectives, principles, concepts, approach, components, steps in implementation of watershed; development of cropping systems for watershed areas.

UNIT IV

Land use capability classification, alternate land use systems; agro-forestry; lay farming; *jhum and taungya* cultivation - basic concepts, socio-ethnic aspects, its layout.

UNIT V

Drainage considerations and agronomic management; rehabilitation of abandoned *jhum* lands and measures to prevent soil erosion.

Practical

- Study of different types of erosion
- Field studies of different soil conservation measures
- Run-off and soil loss measurements
- Laying out run-off plot and deciding treatments
- Identification of different grasses and trees for soil conservation
- Visit to a soil conservation research centre, demonstration and training centre

Suggested Readings

- Arakeri HR & Roy D. 1984. Principles of Soil Conservation and Water Management. Oxford & IBH.
- Dhruvanarayana VV. 1993. Soil and Water Conservation Research in India. ICAR.
- FAO. 2004. Soil and Water Conservation in Semi-Arid Areas. Soils Bull., Paper 57.
- Frederick RT, Hobbs J, Arthur D & Roy L. 1999. Soil and Water Conservation: Productivity and Environment Protection. 3rd Ed. Prentice Hall.
- Gurmel Singh, Venkataraman CG, Sastry B & Joshi P. 1990. Manual of Soil and Water Conservation Practices. Oxford & IBH.
- Murthy VVN. 1995. Land and Water Management Engineering. Kalyani.

❖ Tripathi RP & Singh HP. 1993. Soil Erosion and Conservation. Wiley Eastern.
❖ Yellamanda Reddy T & Sankara Reddy GH. 1992. Principles of Agronomy. Kalyani.

AGRON 609 : STRESS CROP PRODUCTION 2+1

Objective

To study various types of stresses in crop production and strategies to overcome them.

Thery

UNIT I

Stress and strain terminology; nature and stress injury and resistance; causes of stress.

UNIT II

Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature stress through, soil and crop manipulations.

UNIT III

High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

UNIT IV

Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations.

UNIT V

Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.

UNIT VI

Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

UNIT VII

Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance.

UNIT VIII

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

Practical

- Determination of electrical conductivity of plant cell sap
- Determination of osmotic potential and tissue water potential
- Measurement of transpiration rate
- Measurement of stomatal frequency
- Growing of plants in sand culture under salt stress for biochemical and physiological studies
- Studies on effect of osmotic and ionic stress on seed germination and seedling growth
- Measurement of low temperature injury under field conditions

Suggested Readings

❖ Baker FWG.1989. Drought Resistance in Cereals. Oxon, UK.
❖ Gupta U.S. (Ed.). 1988. Physiological Aspects of Dryland Farming. Oxford & IBH.
❖ Kramer PJ.1983. Water Relations of Plants. Academic Press.
❖ Levitt J. 1980. Response of Plants to Environmental Stresses. Vols. I, II. Academic Press.
❖ Mavi HS.1978. Introduction to Agro-meteorology. Oxford & IBH.
❖ Michael AM & Ojha TP.1981. Principles of Agricultural Engineering. Vol II. Jain Bros.
❖ Nilsen ET & Orcut DM. 1996. Physiology of Plants under Stress - Abiotic Factors. John Wiley & Sons.
❖ Singh K. 2000. Plant Productivity under Environmental Stress. Agribios.

- Singh KN & Singh RP. 1990. Agronomic Research Towards Sustainable Agriculture. Indian Society of Agronomy, New Delhi.
- Somani LL & Totawat KL. 1992. Management of Salt-affected Soils and Waters. Agrotech Publ.
- Virmani SM, Katyal JC, Eswaran H & Abrol IP.1994. Stressed Ecosystem and Sustainable Agriculture. Oxford & IBH.

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

SOILS 501 : SOIL PHYSICS 2+1

Objective

To impart basic knowledge about soil physical properties and processes in relation to plant growth.

Theory

Scope of soil physics and its relation with other branches of soil science; soil as a three phase system. Soil texture, textural classes, mechanical analysis, specific surface. Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation. Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential. Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils. Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum. Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management. Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

- Mechanical analysis by pipette and international methods
- Aggregate analysis - dry and wet
- Measurement of soil-water content by different methods
- Measurement of soil-water potential by using tensiometer and gypsum blocks
- Determination of soil-moisture characteristics curve and computation of pore-size distribution
- Determination of hydraulic conductivity under saturated and unsaturated conditions
- Determination of infiltration rate of soil
- Determination of aeration porosity
- Soil temperature measurements by different methods
- Estimation of water balance components in bare and cropped fields

Suggested Readings

- Baver LD, Gardner WH & Gardner WR. 1972. Soil Physics. John Wiley & Sons.
- Ghildyal BP & Tripathi RP. 2001. Soil Physics. New Age International.
- Hanks JR & Ashcroft GL. 1980. Applied Soil Physics. Springer Verlag.
- Hillel D. 1972. Optimizing the Soil Physical Environment toward Greater Crop Yields. Academic Press.
- Hillel D. 1980. Applications of Soil Physics. Academic Press.
- Hillel D. 1980. Fundamentals of Soil Physics. Academic Press.
- Hillel D. 1998. Environmental Soil Physics. Academic Press.

- Hillel D. 2003. Introduction to Environmental Soil Physics. Academic Press.
- Indian Society of Soil Science. 2002. Fundamentals of Soil Science. ISSS, New Delhi.
- Kirkham D & Powers WL. 1972. Advanced Soil Physics. Wiley- Interscience.
- Kohnke H. 1968. Soil Physics. McGraw Hill.
- Lal R & Shukla MK. 2004. Principles of Soil Physics. Marcel Dekker.
- Oswal MC. 1994. Soil Physics. Oxford & IBH.
- Saha AK. 2004. Text Book of Soil Physics. Kalyani.
- Savalia.S.G., Golakiya, B.A. and Patel, S.V. (2009) Soil Physics, Theory and Practices. Kalyani Publishers, Ludhiana.

SOILS 502 : SOIL FERTILITY AND FERTILIZER USE 3+1

Objective

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory

Soil fertility and soil productivity; nutrient sources – fertilizers and manures; essential plant nutrients - functions and deficiency symptoms. Bulky and concentrated organic manures, their composition, characteristics, transformation in soil and their effect on soil productivity Role of manures in sustainable agriculture, Enriched compost preparation, Effect of manures on soil properties, Long term effect of FYM, vermin compost and rural as well as urban compost, Bulky and concentrated manures and their effect on soil properties. Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation - types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency. Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions. Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions. Sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers. Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability. Common soil test methods for fertilizer recommendations; quantity– intensity relationships; soil test crop response correlations and response functions. Fertilizer use efficiency; blanket fertilizer recommendations – usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated nutrient management. Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical

- Principles of colorimetry
- Flame-photometry and atomic absorption spectroscopy
- Chemical analysis of soil for total and available nutrients
- Analysis of plants for essential elements

Suggested Readings

- Brady NC & Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- Kabata-Pendias A & Pendias H. 1992. Trace Elements in Soils and Plants. CRC Press.
- Kannaiyan S, Kumar K & Govindarajan K. 2004. Biofertilizers Technology. Scientific Publ.
- Leigh JG. 2002. Nitrogen Fixation at the Millennium. Elsevier.
- Mengel K & Kirkby EA. 1982. Principles of Plant Nutrition. International Potash Institute, Switzerland.
- Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. Micronutrients in Agriculture. 2nd Ed. SSSA, Madison.
- Pierzinsky GM, Sims TJ & Vance JF. 2002. Soils and Environmental Quality. 2nd Ed. CRC Press.

- Stevenson FJ & Cole MA. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients. John Wiley & Sons.
- Tisdale SL, Nelson SL, Beaton JD & Havlin JL. 1999. Soil Fertility and Fertilizers. 5th Ed. Prentice Hall of India.
- Troeh FR & Thompson LM. 2005. Soils and Soil Fertility. Blackwell.

SOILS 503 : SOIL CHEMISTRY 2+1

Objective

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

Theory

Chemical (elemental) composition of the earth's crust and soils. Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions. Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), Silicate clay mineral, types of silicate clay minerals, characteristics and classification and important in agriculture. AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition. Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects. Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity. Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments. Chemistry and electrochemistry of submerged soils.

Practical

- Determination of CEC and AEC of soils
- Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter
- Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method
- Determination of titratable acidity of an acid soil by BaCl2-TEA method
- Determination of lime requirement of an acid soil by buffer method
- Determination of gypsum requirement of an alkali soil

Suggested Readings

- Bear RE. 1964. Chemistry of the Soil. Oxford and IBH.
- Bolt GH & Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.
- Greenland DJ & Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & Sons.
- Greenland DJ & Hayes MHB. Chemistry of Soil Constituents. John Wiley & Sons.
- McBride MB. 1994. Environmental Chemistry of Soils. Oxford Univ. Press.
- Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford Univ. Press.
- Sposito G. 1984. The Surface Chemistry of Soils. Oxford Univ. Press.
- Sposito G. 1989. The Chemistry of Soils. Oxford Univ. Press.
- Stevenson FJ. 1994. Humus Chemistry. 2nd Ed. John Wiley & Sons.
- Van Olphan H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.

SOILS 504 : SOIL MINERALOGY, GENESIS, CLASSIFICATION AND SURVEY 2+1

Objective

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils. Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils. Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness. Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps. Landform – soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Practical

- Identification of rocks and minerals
- Morphological properties of soil profile in different landforms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soils using available data base in terms of soil quality
- Aerial photo and satellite data interpretation for soil and land use
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales
- Land use planning exercises using conventional and RS tools

Suggested Readings

- Brady NC & Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ.
- Dixon JB & Weed SB. 1989. Minerals in Soil Environments. 2nd Ed. Soil Science Society of America, Madison.
- Grim RE. 1968. Clay Mineralogy. McGraw Hill.
- Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
- Sehgal J. 2002. Introductory Pedology: Concepts and Applications. New Delhi
- Sehgal J. 2002. Pedology - Concepts and Applications. Kalyani.
- USDA. 1999. Soil Taxonomy. Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.
- Wade FA & Mattox RB. 1960. Elements of Crystallography and Mineralogy. Oxford & IBH.
- Wilding LP & Smeck NE. 1983. Pedogenesis and Soil Taxonomy: II. The Soil Orders. Elsevier.
- Wilding NE & Holl GF. (Eds.). 1983. Pedogenesis and Soil Taxonomy. I. Concept and Interaction. Elsevier.

SOILS 505 : SOIL EROSION AND CONSERVATION 2+1

Objective

To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

History, distribution, identification and description of soil erosion problems in India. Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity - estimation as EI30 index and

kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation. Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country. Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout. Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands. Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds.

Practical

- Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rainfall erosivity index (EI30) using rain gauge data
- Visits to a watersheds

Suggested Readings

- ❖ Biswas TD & Narayanasamy G. (Eds.) 1996. Soil Management in Relation to Land Degradation and Environment. Bull. Indian Society of Soil Science No. 17.
- ❖ Doran JW & Jones AJ. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Spl Publ. No. 49, Madison, USA.
- ❖ Gurmal Singh, Venkataramanan C, Sastry G & Joshi BP. 1990. Manual of Soil and Water Conservation Practices. Oxford & IBH.
- ❖ Hudson N. 1995. Soil Conservation. Iowa State Univ. Press.
- ❖ Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
- ❖ Oswal MC. 1994. Soil Physics. Oxford & IBH.

SOILS 506 : SOIL BIOLOGY AND BIOCHEMISTRY 2+1

Objective

To teach students the basics of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota. Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora. Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil. Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost. Biofertilizers – definition, scope, classification, specifications, method of production and role in crop production. Constraint in application of biofertilizers.

Practical

- Determination of soil microbial population
- Soil microbial biomass
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil
- Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N2 fixation, S oxidation, P solubilization and mineralization of other micro nutrients
- Study of rhizosphere effect

Suggested Readings

- Alexander M. 1977. Introduction to Soil Microbiology. John Wiley & Sons.
- Burges A & Raw F. 1967. Soil Biology. Academic Press.
- McLaren AD & Peterson GH. 1967. Soil Biochemistry. Vol. XI. Marcel Dekker.
- Metting FB. 1993. Soil Microbial Ecology – Applications in Agricultural and Environmental Management. Marcel Dekker.
- Paul EA & Ladd JN. 1981. Soil Biochemistry. Marcel Dekker.
- Reddy MV. (Ed.). Soil Organisms and Litter in the Tropics. Oxford & IBH.
- Russel RS. 1977. Plant Root System: Their Functions and Interaction with the Soil. ELBS & McGraw Hill.
- Stotzky G & Bollag JM. 1993. Soil Biochemistry. Vol. VIII. Marcel Dekker.
- Sylvia DN. 2005. Principles and Applications of Soil Microbiology. Pearson Edu.
- Wild A. 1993. Soil and the Environment - An Introduction. Cambridge Univ. Press.

SOILS 507 : GEOMORPHOLOGY AND GEOCHEMISTRY 2+0

Objective

To impart knowledge about the landforms, physiography and morphologyof the earth surface, and distribution and weathering elements in the earth crust.

Theory

General introduction to geology and geochemistry, major and minor morphogenic and genetic landforms, study of schematic landforms and their elements with special reference to India. Methodology of geomorphology, its agencies, erosion and weathering; soil and physiography relationships; erosion surface of soil landscape. Geochemical classification of elements; geo-chemical aspects of weathering and migration of elements; geochemistry of major and micronutrients and trace elements.

Suggested Readings

Brikland PW. 1999. *Soils and Geomorophology*. 3rd Ed. Oxford Univ. Press.
Likens GE & Bormann FH. 1995. *Geochemistry*. 2nd Ed. Springer Verlag.
Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

SOILS 508 : RADIOISOTOPES IN SOIL AND PLANT STUDIES 1+1

Objective

To train students in the use of radioisotopes in soil and plant research

Theory

Atomic structure, radioactivity and units; radioisotopes - properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter. Principles and use of radiation monitoring instruments - proportional, Geiger Muller counter, solid and liquid scintillation counters; neutron moisture meter, mass spectrometry, auto radiography. Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating. Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes

Practical (Theorotical)

- Storage and handling of radioactive materials
- Determination of half life and decay constant
- Preparation of soil and plant samples for radioactive measurements
- Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radioisotopes
- Determination of A, E and L values of soil using 32P/ 65Zn
- Use of neutron probe for moisture determination
- Sample preparation and measurement of 15N enrichment by mass spectrophotometery/ emission spectrometry

Suggested Readings

- Comer CL. 1955. Radioisotopes in Biology and Agriculture: Principles and Practice. Tata McGraw Hill.
- Glasstone S. 1967. Source Book on Atomic Energy. East West Press.
- Michael FL & Annunziata. 2003. Handbook of Radioactivity Analysis. Academic Press.
- Golakiya, B.A., Sakarvadia H.L., Poonam, I Jetpara, Parmar, K.B., Patel, S.V.(2008) Radiotracer techniques for agriculturist and Biologists. New Publishing Agency, New Delhi.

SOILS 509 : SOIL, WATER AND AIR POLLUTION 2+1

Objective

To make the students aware of the problems of soil, water and air pollution associated with use of soils for crop production.

Theory

Soil, water and air pollution problems associated with agriculture, nature and extent. Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants - their CPC standards and effect on plants, animals and human beings. Sewage and industrial effluents – their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal. Pesticides – their classification, behavior in soil and effect on soil microorganisms. Toxic elements – their sources, behavior in soils, effect on nutrients availability, effect on plant and human health. Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases – carbon dioxide, methane and nitrous oxide. Remediation/amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

- Sampling of sewage waters, sewage sludge, solid/liquid industrial wastes, polluted soils and plants
- Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents.
- Heavy metals in contaminated soils and plants
- Determination of free CO2 from the effluent water
- Management of contaminants in soil and plants to safeguard food safety
- Air sampling and determination of particulate matter and oxides of sulphur
- Visit to various industrial sites to study the impact of pollutants on soil and plants

Suggested Readings

- Lal R, Kimble J, Levine E & Stewart BA. 1995. Soil Management and Greenhouse Effect. CRC Press.
- Middlebrooks EJ. 1979. Industrial Pollution Control. Vol. I. Agro- Industries. John Wiley Interscience.
- Ross SM. Toxic Metals in Soil Plant Systems. John Wiley & Sons.
- Vesilund PA & Pierce 1983. Environmental Pollution and Control. Ann Arbor Science Publ.
- Mishra, P.C. (1985) Soil Pollution and Soil Organisms

SOILS 510 : REMOTE SENSING AND GIS TECHNIQUES FOR SOIL, WATER AND CROP STUDIES 2+1

Objective

To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries, and their interpretation; application of remote sensing in general and with special reference to soil, plants and yield forecasting; to impart knowledge about geo-statistical techniques with special reference to krigging, and GIS and applications in agriculture.

Theory

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter. Sensor systems - camera, microwave radiometers and scanners; fundamentals of aerial photographs and image processing and interpretations. Application of remote sensing techniques - land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, wasteland identification and management. Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evaluation of soil variability. Introduction to GIS and its application for spatial and non-spatial soil and land attributes.

Practical

- Familiarization with different remote sensing equipments and data products
- Interpretation of aerial photographs and satellite data for mapping of land resources
- Analysis of variability of different soil properties with classical and geostatistical techniques
- Creation of data files in a database programme
- Use of GIS for soil spatial simulation and analysis
- To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning

Suggested Readings

- Brady NC & Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- Elangovan K. 2006. GIS Fundamentals, Applications and Implementations. New India Publ. Agency.
- Lillesand TM & Kiefer RW. 1994. Remote Sensing and Image Interpretation. 3rd Ed. Wiley.
- Nielsen DR & Wendroth O. 2003. Spatial and Temporal Statistics. Catena Verloggmbh.
- Star J & Esles J. 1990. Geographic Information System: An Introduction. Prentice Hall.

SOILS 511 : ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS 0+2

Objective

To familiarize the students with commonly used instruments – their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Practical

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling. Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils. Principles of visible, ultraviolet and infrared spectrophotometery, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometery; identification of minerals by X-ray by different methods. determination of cation and anion exchange capacities of soils; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity. Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods. Determination of lime and gypsum requirement of soil. Analysis of soil extracts and irrigation waters for their soluble cations and anions and interpretation of results.

Suggested Readings

- Hesse P. 971. Textbook of Soil Chemical Analysis. William Clowes & Sons.
- Jackson ML. 1967. Soil Chemical Analysis. Prentice Hall of India.
- Keith A Smith 1991. Soil Analysis; Modern Instrumental Techniques. Marcel Dekker.
- Kenneth Helrich 1990. Official Methods of Analysis. Association of Official Analytical Chemists.

- Page AL, Miller RH & Keeney DR. 1982. Methods of Soil Analysis. Part II. SSSA, Madison.
- Piper CE. Soil and Plant Analysis. Hans Publ.
- Singh D, Chhonkar PK & Pandey RN. 1999. Soil Plant Water Analysis – A Methods Manual. IARI, New Delhi.
- Tan KH. 2003. Soil Sampling, Preparation and Analysis. CRC Press/Taylor & Francis.
- Tandon HLS. 1993. Methods of Analysis of Soils, Fertilizers and Waters. FDCO, New Delhi.
- Vogel A.L. 1979. A Textbook of Quantitative Inorganic Analysis. ELBS Longman.

SOILS 512 : SYSTEM APPROACHES IN SOIL AND CROP STUDIES 2+1

Objective

To train the students in concepts, methodology, technology and use of systems simulation in soil and crops studies.

Theory

Systems concepts - definitions, general characteristics; general systems theory; systems thinking, systems dynamics, systems behavior and systems study. Model: definition and types; mathematical models and their types; modeling: concepts, objectives, processes, abstraction techniques; simulation models, their verification and validation, calibration; representation of continuous systems simulation models - procedural and declarative. Simulation - meaning and threats; simulation experiment, its design and analysis. Application of simulation models in understanding system behavior, optimizing system performance, evaluation of policy options under different soil, water, nutrient, climatic and cultural conditions; decision support system, use of simulation models in decision support system.

Practical

- Use of flow chart or pseudo-code in the program writing
- Writing a small example simulation model program - declarative (in Vensim PLE, Stella or Simile) and procedural (in Java, Fortran, QBasic or V Basic)
- Conducting simulation experiments in DSSAT, WOFOST or EPIC with requirement of report and conclusion

Suggested Readings

- Benbi DK & Nieder R. (Eds.). 2003. Handbook of Processes and Modelling in the Soil - Plant System. Haworth Press.
- Hanks J & Ritchie JT. (Eds.). 1991. Modelling Plant and Soil System. Agronomy. Bull. No 31. Soil Sci. Society of America, Madison.
- Rajaraman V. 2004. Computer Programming in Fortran 90 and 95. PHI.
- Tsuji GY, Gerrit H & Philip T. 1998. Understanding Options for Agricultural Production. Kluwer.
- von Bertalanffy Ludwig 1969. General Systems Theory: Foundation Development and Application. Revised Ed. George Braziller Reprint 1998.

Web sites

- Documentation of the respective models. (http://www.simulistics.com/ for Simile; http://www.iseesystems.com for Stella;and http://www.vensim.com/software.html for vensim PLE)
- http://www.icasa.net/dssat/index.html for DSSAT;
- http://www.brc.tamus.edu/epic/ for EPIC
- http://www.nrel.colostate.edu/projects/century/ for Century
- http://www.alterra.wur.nl/NL/for WOFOST
- http://www.apsru.gov.au/ apsru/Default.htm for APSIM
- http://eco.wiz.uni-kassel.de/ecobas.html online Register of ecological models
- Plentinger MC Penning de Vries FWT, Editors (1996) CAMASE Register of Agro-ecosystems Models. DLO-Research Institute for Agrobiology and Soil Fertility (AB-DLO)
- Agricultural Systems – Elsevier at http://www.elsevier.com/wps/product/cws_home /405851

- Ecological Modeling – Elsevier at http://www.elsevier.com/locate/ecolmodel

SOILS 513 : MANAGEMENT OF PROBLEM SOILS AND WATERS 2+1

Objective

To educate students about basic concepts of problem soils and brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.

Theory

Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible**.** Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties. Management of salt-affected soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic, calcareous and dry land soils. Acid soils - nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management. Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality. Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

Practical

- Characterization of acid, acid sulfate, salt-affected and calcareous soils
- Determination of cations (Na+, K+, Ca++ and Mg++) in ground water and soil samples
- Determination of anions (Cl-, SO4-, CO3-- and HCO3-) in ground waters and soil samples
- Lime and gypsum requirements of acid and sodic soils

Suggested Readings

- Bear FE. 1964. Chemistry of the Soil. Oxford & IBH.
- Jurinak JJ. 1978. Salt-affected Soils. Department of Soil Science & Biometeorology. Utah State Univ.
- USDA Handbook No. 60. 1954. Diagnosis and improvement of Saline and Alkali Soils. Oxford & IBH.

SOILS 514 : FERTILIZER TECHNOLOGY 1+0

Objective

To impart knowledge about how different fertilizers are manufactured using different kinds of raw materials and handling of fertilizers and manures.

Theory

Fertilizers – production, consumption and future projections with regard to nutrient use in the country and respective states; fertilizer control order. Manufacturing processes for different fertilizers using various raw materials, characteristics and nutrient contents. Recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order. New and emerging issues in fertilizer technology – production and use of slow and controlled release fertilizers, super granules fertilizers and fertilizers for specific crops/situations.

Suggested Readings

- Brady NC & Weil RR. 2002. The Nature and Properties of Soils. Pearson Edu.
- Fertilizer (Control) Order, 1985 and the Essential Commodities Act. FAI New Delhi.
- Kanwar JS. (Ed.). 1976. Soil Fertility: Theory and Practice. ICAR.
- Olson RA, Army TS, Hanway JJ & Kilmer VJ. 1971. Fertilizer Technology and Use. 2nd Ed. Soil Sci. Soc. Am. Madison.
- Prasad R & Power JF. Soil Fertility Management for Sustainable Agriculture. CRC Press.
- Tisdale SL, Nelson SL, Beaton JD & Havlin JL. 1999. Soil Fertility and Fertilizers. McMillan Publ.
- Vogel AI. 1979. Textbook of Quantitative Inorganic Analysis. ELBS.

SOILS 515 : LAND DEGRADATION AND RESTORATION 1+0

Objective

To impart knowledge related to various factors and processes of land degradation and their restoration techniques.

Theory

Type, factors and processes of soil/land degradation and its impact on soil productivity, including soil fauna, biodegradation and environment. Land restoration and conservation techniques - erosion control, reclamation of salt-affected soils; mine land reclamation, afforestation, organic products. Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

Suggested Readings

- Biswas TD & Narayanasamy G. (Eds.). 1996. Soil Management in Relation to Land Degradation and Environment. Bull. Indian Soc. Soil Sci. 17, New Delhi.
- Doran JW & Jones AJ. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Madison.
- Greenland DJ & Szabolcs I. 1994. Soil Resilience and Sustainable Land Use. CABI.
- Lal R, Blum WEH, Vailentine C & Stewart BA. 1997. Methods for Assessment of Soil Degradation. CRC Press.
- Sehgal J & Abrol IP. 1994. Soil Degradation in India - Status and Impact. Oxford & IBH.

SOILS 601 : ADVANCES IN SOIL PHYSICS 2+0

Objective

To provide knowledge of modern concepts in soil physics.

Theory

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system. Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow. Theories of horizontal and vertical infiltration under different boundary conditions. Movement of salts in soils, models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves. Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil. Soil crust and clod formation; structural management of puddled rice soils; soil conditioning- concept, soils conditioners - types, characteristics, working principles, significance in agriculture. Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer.

Suggested Readings

- Baver LD, Gardner WH & Gardner WR. 1972. Soil Physics. John Wiley & Sons.
- Hanks and Ascheroft. 1980. Applied Soil Physics. Springer Verlag.
- Hillel D. 1980. Applications of Soil Physics. Academic Press.
- Hillel D. 1980. Environmental Soil Physics. Academic Press.
- Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS, New Delhi.
- Kirkham D & Powers WL. 1972. Advanced Soil Physics. WileyInter science.
- Lal R & Shukla MK. 2004. Principles of Soil Physics. Marcel Dekker.
- Oswal MC.1994. Soil Physics. Oxford & IBH. 101

SOILS 602 : ADVANCES IN SOIL FERTILITY 2+0

Objective

To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

Theory

Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices. Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils. Chemical equilibria (including solid-solution equilbria) involving nutrient ions in soils, particularly in submerged soils. Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting. Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture. Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Suggested Readings

- Barber SA. 1995. Soil Nutrient Bioavailability. John Wiley & Sons.
- Barker V Allen & Pilbeam David J. 2007. Handbook of Plant Nutrition. CRC / Taylor & Francis.
- Brady NC & Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Educ.
- Cooke GW. 1979. The Control of Soil Fertility. Crossby Lockwood & Sons.
- Epstein E. 1987. Mineral Nutrition of Plants - Principles and Perspectives. International Potash Institute, Switzerland.
- Kabata- Pendias Alina 2001. Trace Elements in Soils and Plants. CRC / Taylor & Francis.
- Kannaiyan S, Kumar K & Govindarajan K. 2004. Biofertilizers Technology. Scientific Publ.
- Mortvedt JJ, Shuman LM, Cox FR & Welch RM. (Eds.). 1991. Micronutrients in Agriculture. 2nd Ed. Soil Science Society of America, Madison.
- Prasad R & Power JF. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press.
- Stevenson FJ & Cole MA. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients. John Wiley & Sons.
- Stevenson FJ. (Ed.). 1982. Nitrogen in Agricultural Soils. Soil Science Society of America, Madison. 102
- Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1990. Soil Fertility and Fertilizers. 5th Ed. Macmillan Publ.
- Wild A. (Ed.). 1988. Russell's Soil Conditions and Plant Growth. 11th Ed. Longman.

SOILS 603 : PHYSICAL CHEMISTRY OF SOILS 2+0

Objective

To impart knowledge about modern concepts of physical chemistry of soils and clays, with emphasis on understanding the processes involved with practical significance.

Theory

Colloidal chemistry of inorganic and organic components of soils – their formation, clay organic interaction. Predictive approaches for cation exchange equilibria - thermodynamics, empirical and diffuse double layer theory (DDL) - relationships among different selectivity coefficients; structure and properties of diffuse double layer. Thermodynamics of nutrient transformations in soils; cationic and anionic exchange and their models, molecular interaction. Adsorption/desorption isotherms - Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system). Common solubility equilibria - carbonates, iron oxide and

hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

Suggested Readings

- Bear RE. 1964. Chemistry of the Soil. Oxford & IBH.
- Bolt GH & Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.
- Fried M & Broeshart H. 1967. Soil Plant System in Relation to Inorganic Nutrition. Academic Press.
- Greenland DJ & Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & Sons.
- Greenland DJ & Hayes MHB. 1978. Chemistry of Soil Constituents. John Wiley & Sons.
- Jurinak JJ. 1978. Chemistry of Aquatic Systems. Dept. of Soil Science & Biometeorology, Utah State Univ.
- McBride MB. 1994. Environmental Chemistry of Soils. Oxford Univ. Press.
- Sparks DL. 1999. Soil Physical Chemistry. 2nd Ed. CRC Press.
- Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford Univ. Press.
- Sposito G. 1984. The Surface Chemistry of Soils. Oxford Univ. Press.
- Sposito G. 1989. The Chemistry of Soils. Oxford Univ. Press.
- Stevenson FJ. 1994. Humus Chemistry. 2nd Ed. John Wiley. 103
- Van Olphan H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.

SOILS 604 : SOIL GENESIS AND MICROPEDOLOGY 2+0

Objective

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

Theory

Pedogenic evolution of soils; soil composition and characterization. Weathering and soil formation – factors and pedogenic processes; stability and weathering sequences of minerals. Assessment of soil profile development by mineralogical and chemical analysis. Micro-pedological features of soils – their structure, fabric analysis, role in genesis and classification.

Suggested Readings

- Boul SW, Hole ED, MacCraken RJ & Southard RJ. 1997. Soil Genesis and Classification. 4th Ed. Panima Publ.
- Brewer R. 1976. Fabric and Mineral Analysis of Soils. John Wiley & Sons.

SOILS 605 : BIOCHEMISTRY OF SOIL ORGANIC MATTER 2+0

Objective

To impart knowledge related to chemistry and reactions of organic substances and their significance in soils.

Theory

Organic matter pools in soil; composition and distribution of organic matter in soil and its functions; environmental significance of humic substances; decomposition of organic residues in soil in relation to organic matter pools. Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids. Nutrient transformation–N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils. Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay-organic matter complexes. Humus - pesticide interactions in soil, mechanisms.

Suggested Readings

- Beck AJ, Jones KC, Hayes MHB & Mingelgrin U. 1993. Organic Substances in Soil and Water: Natural Constituents and their Influences on Contaminant Behavior. Royal Society of Chemistry, London.
- Gieseking JE. 1975. Soil Components. Vol. 1. Organic Components. Springer-Verlag.
- Kristiansen P, Taji A & Reganold J. 2006. Organic Agriculture: A Global Perspective. CSIRO Publ.

- Magdoff F & Weil RR 2004. Soil Organic Matter in Sustainable Agriculture. CRC Press.
- Mercky R & Mulongoy K. 1991. Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture. John Wiley & Sons.
- Paul EA. 1996. Soil Microbiology and Biochemistry. Academic Press.
- Stevenson FJ. 1994. Humus Chemistry – Genesis, Composition and Reactions. John Wiley & Sons.

SOILS 606 : LAND USE PLANNING AND WATERSHED MANAGEMENT 2+0

Objective

To teach the better utilization of land for agricultural purposes, and better management of run-off or surplus/excessive rain-water in the catchment area for agricultural purposes in a watershed.

Theory

Concept and techniques of land use planning; factors governing present land use. Land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application. Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production. Water harvesting - concept, significance, types, methodology; use of harvested water in agriculture to increase water productivity. Watershed development/management - concept, objectives, characterization, planning, execution, community participation and evaluation; rehabilitation of watershed; PRA; developing economically and ecologically sustainable agro-forestry systems for watershed; case studies.

Suggested Readings

- All India Soil and Land Use Survey Organisation 1970. Soil Survey Manual. IARI, New Delhi.
- FAO. 1976. A Framework for Land Evaluation, Handbook 32. FAO.
- Sehgal JL, Mandal DK, Mandal C & Vadivelu S. 1990. Agro-Ecological Regions of India. NBSS & LUP, Nagpur.
- Soil Survey Staff 1998. Keys to Soil Taxonomy. 8th Ed. USDA & NRCS, Washington, DC.
- USDA 1974. A Manual on Conservation of Soil and Water Handbook of Professional Agricultural Workers. Oxford & IBH.

ENTOMOLOGY

ENT 501 : INSECT MORPHOLOGY 1+1

Objective

To acquaint the students with external morphology of the insect's body i.e.;head, thorax and abdomen, their appendages and functions.

Theory

UNIT I

Principles, utility and relevance: insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation.

UNIT II

Head- Origin, structure and modification; tentorium and neck sclerites.

UNIT III

Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; Wings: Structure and modifications, venation, and mechanism of flight; Legs: structure Hexapod locomotion

UNIT IV

Abdomen- Segmentation and appendages; Genitalia and their modifications; Embryonic and post-embryonic development; Types of metamorphosis. Insect sense organs (mechano-, photo- and chemoreceptors).

Practical

Study of insect segmentation, various tagmata and their appendages; preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia. Sense organs.

Suggested Readings

- Chapman RF. 1998. The Insects: Structure and Function. Cambridge Univ. Press, Cambridge.
- David BV & Ananthkrishnan TN. 2004. General and Applied Entomology. Tata-McGraw Hill, New Delhi.
- Duntson PA. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publ., New Delhi.
- Evans JW. 2004. Outlines of Agricultural Entomology. Asiatic Publ., New Delhi.
- Richards OW & Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman & Hall, London.
- Saxena RC & Srivastava RC. 2007. Entomology: At a Glance. Agrotech Publ. Academy, Jodhpur.
- Snodgross RE. 1993. Principles of Insect Morphology. Cornell Univ. Press, Ithaca.

ENT 502 : INSECTANATOMY, PHYSIOLOGY AND NUTRITION 2+1

Objective

To impart knowledge to the students on basic aspects of anatomy of different systems, elementary physiology, nutritional physiology and their application in entomology.

Theory

UNIT I

Scope and importance of insect anatomy and physiology.

UNIT II

Structure, modification and physiology of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands [*More weightage on physiology*].

UNIT III

Thermodynamics; physiology of integument, moulting; growth, metamorphosis and diapause.

UNIT IV

Insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.

Practical

Dissection of different insects to study comparative anatomical details of different systems; preparation of permanent mounts of internal systems; chromatographic analysis of free amino acids of haemolymph; determination of chitin in insect cuticle; examination of insect haemocytes; determination of respiratory quotient; preparation and evaluation of various diets; consumption, utilization and digestion of natural and artificial diets.

Suggested Readings

- Chapman RF.1998. Insects: Structure and Function. ELBS Ed., London.
- Duntson PA. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publ., New Delhi.
- Kerkut GA & Gilbert LI. 1985. Comprehensive Insect Physiology,Biochemistry and Pharmacology. Vols. I-XIII. Pergamon Press, New York.
- Patnaik BD. 2002. Physiology of Insects. Dominant, New Delhi.
- Richards OW & Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Vol. 1. Structure, Physiology and Development. Chapman & Hall, New York.

- Saxena RC & Srivastava RC. 2007. Entomology at a Glance. Agrotech Publ. Academy, Jodhpur.
- Wigglesworth VB.1984. Insect Physiology. 8th Ed. Chapman & Hall, New York.

ENT 503/ NEMA 502 : PRINCIPLES OF TAXONOMY 2+0

Objective

To sensitize the students on the theory and practice of classifying organisms and the rules governing the same.

Theory

UNIT I

Introduction to history and principles of systematics and importance. Levels and functions of systematics. Identification, purpose, methods, character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy vs homology, parallel vs convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism.

UNIT II

Classification of animals: Schools of classification- Phenetics, Cladistics and Evolutionary classification. Components of Biological Classification: Hierarchy, Rank, Category and Taxon. Species concepts, cryptic, sibling and etho-species, infra-specific categories. Introduction to numerical, biological and cytogenetical taxonomy.

UNIT III

Nomenclature: Common vs Scientific names. International Code of Zoological Nomenclature, criteria for availability of names, validity of names. Categories of names under consideration of ICZN. Taxonomic publications, Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature. Speciation, anagenesis vs cladogenesis, allopatric, sympatric and parapatric processes.

Suggested Readings

- Blackwelder RE. 1967. Taxonomy - A Text and Reference Book. John Wiley & Sons, New York.
- Kapoor VC. 1983. Theory and Practice in Animal Taxonomy. Oxford & IBH, New Delhi.
- Mayr E. 1971. Principles of Systematic Zoology. Tata McGraw-Hill, New Delhi.
- Quicke DLJ. 1993. Principles and Techniques of Contemporary Taxonomy. Blackie, London.

ENT 504 : CLASSIFICATION OF INSECTS 2+1

Objective

To introduce the students to the classification of insects up to the level of families with hands-on experience in identifying the families of insects.

Theory

UNIT I

Brief evolutionary history of Insects- introduction to phylogeny of insects and Major Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- Orders contained.

UNIT II

Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.

UNIT III

Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera,

Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

Practical

Study of Orders of insects and their identification using taxonomic keys. Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera. Field visits to collect insects of different orders.

Suggested Readings

- CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2nd Vols. I & II, CSIRO. Cornell Univ. Press, Ithaca.
- Freeman S & Herron JC. 1998. Evolutionary Analysis. Prentice Hall, New Delhi.
- Richards OW & Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman & Hall, London.
- Ross HH.1974. Biological Systematics. Addison Wesley Publ. Co. Triplehorn CA & ohnson NF. 1998. Borror and DeLong's Introduction to the Study of Insects. 7th Ed. Thomson/ Brooks/ Cole, USA/Australia.

ENT 505 : INSECT ECOLOGY 1+1

Objective

To teach the students the concepts of ecology, basic principles of distribution and abundance of organisms and their causes. Study life tables, organization of communities, diversity indicies. Train students in sampling methodology, calculation of diversity indicies, constructing life tables, relating insect population fluctuations to biotic and/or abiotic causes.

Theory

UNIT I

History and Definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance vs Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects-Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology.

UNIT II

Basic concepts of abundance- Model vs Real world. Population growthbasic models – Exponential vs Logistic models. Discrete vs Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) - aestivation, hibernation.

UNIT III

Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions - The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of nicheecological homologues, competitive exclusion. Prey-predator interactions-Basic model- Lotka-Volterra Model, Volterra's principle. Functional and numerical response. Defense mechanisms against predators/parasitoids- Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.

UNIT IV

Community ecology- Concept of guild, Organisation of communities- Hutchinson Ratio, May's *d/w*, Relation between the two and their association with Dyar's Law and Przibram's law. Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity- stability debate, relevance to pest management. Pest management as applied ecology.

Practical

Types of distributions of organisms. Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution. Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit. Fitting Holling's Disc equation, Assessment of prey-predator densities from natural systems and understanding the correlation between the two. Assessing and describing niche of some insects of a single guild. Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms. Calculation of some diversityindices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values. Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

Suggested Readings

- Chapman JL & Reiss MJ. 2006. Ecology: Principles & Applications. 2nd Ed. Cambridge Univ. Press, Cambridge.
- Gotelli NJ & Ellison AM. 2004. A Primer of Ecological Statistics. Sinauer Associates, Inc., Sunderland, MA.
- Gotelli NJ. 2001. A Primer of Ecology. 3rd Ed. Sinauer Associates, Inc., Sunderland, MA
- Gupta RK. 2004. Advances in Insect Biodiversity. Agrobios, Jodhpur.
- Krebs CJ. 1998. Ecological Methodology. 2nd Ed. Benjamin-Cummings Publ. Co., New York.
- Krebs CJ. 2001. Ecology: The Experimental Analysis of Distribution and Abundance. 5th Ed. Benjamin-Cummings Publ. Co., New York.
- Magurran AE. 1988. Ecological Diversity and its Measurement. Princeton Univ. Press, Princeton.
- Price PW. 1997. Insect Ecology. 3rd Ed. John Wiley, New York.
- Real LA & Brown JH. (Eds). 1991. Foundations of Ecology: Classic Papers with Commentaries. University of Chicago Press, Chicago.
- Southwood TRE & Henderson PA. 2000. Ecological Methods. 3rd Ed. Methuen & Co. Ltd., London.
- Speight MR, Hunta MD & Watt AD. 2006. Ecology of Insects: Concepts and Application. Elsevier Science Publ., The Netherlands.
- Wilson EO & William H Bossert WH. 1971. A Primer of Population
- Biology. Harvard University, USA.
- Wratten SD & Fry GLA.1980. Field and Laboratory Exercises in Ecology. Arnold, London.

ENT 506 : INSECT PATHOLOGY 1+1

Objective

To teach the students about various microbes that are pathogenic to insects, factors that affect their virulence; provide hands-on training in identification, isolation, culturing various pathogens and assessing pathogenicity.

Theory

UNIT I

History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.

UNIT II

Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

UNIT III

Examples of successful instances of exploitation of pathogens for pest management and mass production techniques of pathogens. Safety and registration of microbial pesticides. Use of insect pathogens in integrated management of insect pests.

Practical

Familiarization with equipment used in insect pathology laboratory. Identification of different groups of insect pathogens and symptoms of infection. Isolation, culturing and testing pathogenicity of different groups of pathogens. Testing Koch's postulates. Estimation of pathogen load. Extraction of pathogens from live organisms and soil. Bioassays to determine median lethal doses.

Suggested Readings

- Boucias DG & Pendland JC. 1998. Principles of Insect Pathology. Kluwer Academic Publisher, Norwel.
- Burges HD & Hussey NW. (Eds). 1971. Microbial Control of Insects and Mites. Academic Press, London.
- Steinhaus EA. 1984. Principles of Insect Pathology. Academic Press, London.

ENT 507 BIOLOGICAL CONTROL OF CROP PESTS AND WEEDS 1+1

Objective

To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

Theory

UNIT I

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation.

UNIT II

Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Biological control of weeds using insects and pathogens.

UNIT III

Mass production of quality biocontrol agents- techniques, formulations, economics, field release/application and evaluation.

UNIT IV

Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

Practical

Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers. Visits (only where logistically feasible) to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds. Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

Suggested Readings

- Burges HD & Hussey NW. (Eds). 1971. Microbial Control of Insects and Mites. Academic Press, London.
- De Bach P. 1964. Biological Control of Insect Pests and Weeds. Chapman & Hall, New York.
- Dhaliwal GS & Arora R. 2001. Integrated Pest Management: Concepts and Approaches. Kalyani Publ., New Delhi.
- Gerson H & Smiley RL. 1990. Acarine Biocontrol Agents – An Illustrated Key and Manual. Chapman & Hall, New York.
- Huffaker CB & Messenger PS. 1976. Theory and Practices of Biological Control. Academic Press, London.
- Ignacimuthu SS & Jayaraj S. 2003. Biological Control of Insect Pests. Phoenix Publ., New Delhi.
- Saxena AB. 2003. Biological Control of Insect Pests. Anmol Publ., New Delhi.

❖ Van Driesche & Bellows TS. Jr. 1996. Biological Control. Chapman & Hall, New York.

ENT 508 : TOXICOLOGY OF INSECTICIDES 2+1

Objective

To orient the students with structure and mode of action of important insecticides belonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

Theory

UNIT I

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

UNIT II

Classification of insecticides and acaricides based on mode of entry, mode of action, toxicity and chemical nature. Structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds, etc.

UNIT III

Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides-synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phyto-toxicity.

UNIT IV

Insecticide metabolism; pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

UNIT V

Insecticide residues, their significance and environmental implications. Insecticide Act, registration and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Practical

Insecticide formulations and mixtures; quality control of pesticide formulations; laboratory and field evaluation of bioefficacy of insecticides; bioassay techniques; probit analysis; evaluation of insecticide toxicity and joint action. Toxicity to beneficial insects. Pesticide appliances. Working out doses and concentrations of pesticides; visit to toxicology laboratories. Good laboratory practices.

Suggested Readings

❖ Chattopadhyay SB. 1985. Principles and Procedures of Plant Protection. Oxford & IBH, New Delhi.
❖ Gupta HCL.1999. Insecticides: Toxicology and Uses. Agrotech Publ., Udaipur.
❖ Ishaaya I & Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.
❖ Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York.
❖ Perry AS, Yamamoto I, Ishaaya I & Perry R. 1998. Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi.
❖ Prakash A & Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publ., New York.

ENT 509 : PLANT RESISTANCE TO INSECTS 1+1

Objective

To familiarize the students with types, basis, mechanisms and genetics of resistance in plants to insects and role of plant resistance in pest management.

Theory

UNIT I

History and importance of resistance, principles, classification, components, types and mechanisms of resistance.

UNIT II

Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

UNIT III

Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance - acquired and induced systemic resistance.

UNIT IV

Factors affecting plant resistance including biotypes and measures to combat them.

UNIT V

Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

UNIT VI

Role of biotechnology in plant resistance to insects.

Practical

Screening techniques for measuring resistance; measurement of plant characters and working out their correlations with plant resistance; testing of resistance in important crops; bioassay of plant extracts of susceptible/resistant varieties; demonstration of antibiosis, tolerance and antixenosis.

Suggested Readings

- Dhaliwal GS & Singh R. (Eds). 2004. Host Plant Resistance to Insects - Concepts and Applications. Panima Publ., New Delhi.
- Maxwell FG & Jennings PR. (Eds). 1980. Breeding Plants Resistant to Insects. John Wiley & Sons, New York.
- Painter RH.1951. Insect Resistance in Crop Plants. MacMillan, London. Panda
- N & Khush GS. 1995. Plant Resistance to Insects. CABI, London.
- Smith CM. 2005. Plant Resistance to Arthropods – Molecular and Conventional Approaches. Springer, Berlin.

ENT 510/ NEMA 510 : PRINCIPLES OF INTEGRATED PEST MANAGEMENT 1+1

Objective

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM**.** Train students in computation of ETL, implementing IPM programmes.

Theory

UNIT I

History and origin, definition and evolution of various related terminologies.

UNIT II

Concept and philosophy, ecological principles, economic threshold concept, and economic consideration.

UNIT III

Tools of pest management and their integration- legislative, cultural, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

Practical

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessmentdirect losses, indirect losses, potential losses, avoidable losses, unavoidable losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system.

Suggested Readings

- Dhaliwal GS & Arora R. 2003. Integrated Pest Management – Concepts and Approaches. Kalyani Publ., New Delhi.
- Dhaliwal GS, Singh R & Chhillar BS. 2006. Essentials of Agricultural Entomology. Kalyani Publ., New Delhi.
- Flint MC & Bosch RV. 1981. Introduction to Integrated Pest Management. 1st Ed., Springer, New York.

- Horowitz AR & Ishaaya I. 2004. Insect Pest Management: Field and Protected Crops. Springer, New Delhi.
- Ignacimuthu SS & Jayaraj S. 2007. Biotechnology and Insect PestManagement. Elite Publ., New Delhi.
- Metcalf RL & Luckman WH. 1982. Introduction of Insect Pest Management. John Wiley & Sons, New York.
- Pedigo RL. 2002. Entomology and Pest Management. 4th Ed. Prentice Hall, New Delhi.
- Norris RF, Caswell-Chen EP & Kogan M. 2002. Concepts in Integrated Pest Management. Prentice Hall, New Delhi.
- Subramanyam B & Hagstrum DW. 1995. Integrated Management of Insects in Stored Products. Marcel Dekker, New York.

ENT 511 : PESTS OF FIELD CROPS 1+1

Objective

To familiarize the students about nature of damage and seasonal incidence of insect pests that cause loss to major field crops and their effective management by different methods.

Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors.

UNIT I

Insect pests of cereals and millets and their management. Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs etc.).

UNIT II

Insect pests of pulses, tobacco, oilseeds and their management.

UNIT III

Insect pests of fibre crops, forages, sugarcane and their management.

Practical

Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops; study of life history of important insect pests.

Suggested Readings

- Atwal AS, Dhaliwal GS & David BV. 2001. Elements of Economic Entomology. Popular Book Depot, Chennai.
- Dhaliwal GS, Singh R & Chhillar BS. 2006. Essentials of Agricultural Entomology. Kalyani Publ., New Delhi.
- Dunston AP. 2007. The Insects: Beneficial and Harmful Aspects. Kalyani Publ., New Delhi
- Evans JW. 2005. Insect Pests and their Control. Asiatic Publ., New Delhi.
- Nair MRGK. 1986. Insect and Mites of Crops in India. ICAR, New Delhi.
- Prakash I & Mathur RP. 1987. Management of Rodent Pests. ICAR, New Delhi.
- Saxena RC & Srivastava RC. 2007. Entomology at a Glance. Agrotech Publ. Academy, Jodhpur.

ENT 512 : PESTS OF HORTICULTURAL AND PLANTATION CROPS 1+1

Objective

To impart knowledge on major pests of horticultural and plantation crops regarding the extent and nature of loss, seasonal history, their integrated management.

Theory

Systematic position, identification, distribution, host range, bionomics and seasonal bundance, nature and extent of damage and management of insect pests of various crops.

UNIT I

Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits.

UNIT II

Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, French beans, chow-chow, brinjal, okra, all gourds, gherkin, drumstick, leafy vegetables etc.

UNIT III

Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine etc.

UNIT IV

Ornamental, medicinal and aromatic plants and pests in polyhouses/protected cultivation.

Practical

Collection and identification of important pests and their natural enemies on different crops; study of life history of important insect pests and noninsect pests.

Suggested Readings

- Atwal AS & Dhaliwal GS. 2002. Agricultural Pests of South Asia and their Management. Kalyani Publ., New Delhi.
- Butani DK & Jotwani MG. 1984. Insects and Vegetables. Periodical Expert Book Agency, New Delhi.
- Dhaliwal GS, Singh R & Chhillar BS. 2006. Essential of Agricultural Entomology. Kalyani Publ., New Delhi.
- Srivastava RP.1997. Mango Insect Pest Management. International Book Distr., Dehra Dun.
- Verma LR, Verma AK & Goutham DC. 2004. Pest Management in Horticulture Crops : Principles and Practices. Asiatech Publ., New Delhi.

ENT 513 : STORAGE ENTOMOLOGY 1+1

Objective

To focus on requirement and importance of grain and grain storage, to understand the role of stored grain pests and to acquaint with various stored grain pest management techniques for avoiding losses in storage.

Theory

UNIT I

Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses *in toto visà-vis* total production of food grains in India. Scientific and socio-economic factors responsible for grain losses.

UNIT II

Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.

UNIT III

Ecology of insect pests of stored commodities/grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.

UNIT IV

Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/sanitation, disinfestations of stores/receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical control- prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Integrated approaches to stored grain pest management.

Practical

Collection, identification and familiarization with the stored grains/seed insect pests and nature of damage caused by them; detection of insect infestation in stored food grains; estimation of losses in stored food grains; determination of moisture content in stored food grains; familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques; treatment of packing materials and their effect on seed quality. Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, IGSMRI, Hapur etc. (only where logistically feasible).

Suggesting Readings

- Hall DW. 1970. Handling and Storage of Food Grains in Tropical and Subtropical Areas. FAO. Agricultural Development Paper No. 90 and FAO, Plant Production and Protection Series No. 19, FAO, Rome.
- Jayas DV, White NDG & Muir WE. 1995. Stored Grain Ecosystem. Marcel Dekker, New York.
- Khader V. 2004. Textbook on Food Storage and Preservation. Kalyani Publ., New Delhi.
- Khare BP. 1994. Stored Grain Pests and Their Management. Kalyani Publ., New Delhi.
- Subramanyam B & Hagstrum DW. 1995. Interrelated Management of Insects in Stored Products. Marcel Dekker, New York.

ENT 514 / PL.PATH 514 : INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS 1+1

Objective

To teach the students about the different groups of insects that vector plant pathogens, vector-plant pathogen interaction, management of vectors for controlling diseases.

Theory

UNIT I

History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission. (to be taught by Entomologist)

UNIT II

Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors. (unit II to V to be taught by Pl.Pathologist)

UNIT III

Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.

UNIT IV

Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.

UNIT V

Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

Practical

Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; (to be taught by Entomologist) demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies. (to be taught by Pl.Pathologist)

Suggested Readings

- Basu AN. 1995. Bemisia tabaci (Gennadius) - Crop Pest and Principal Whitefly Vector of Plant Viruses. Oxford & IBH, New Delhi.
- Harris KF & Maramarosh K. (Eds.).1980. Vectors of Plant Pathogens. Academic Press, London.
- Maramorosch K & Harris KF. (Eds.). 1979. Leafhopper Vectors and Plant Disease Agents. Academic Press, London.
- Youdeovei A & Service MW. 1983. Pest and Vector Management in the Tropics. English Language Books Series, Longman, London.

ENT 515 : GENERAL ACAROLOGY 1+1

Objective

To aquaint the students with external morphology of different groups of mites, train in identification of commonly occurring families of plant associated mites, provide information about important mite pests of crops and their management.

Theory

UNIT I

History of Acarology; importance of mites as a group; habitat, collection and preservation of mites.

UNIT II

Introduction to morphology and biology of mites and ticks. Broad classification- major orders and important families of Acari including diagnostic characteristics.

UNIT III

Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens *etc*. Culturing of phytophagous, parasitic and predatory mites.

Practical

Collection of mites from plants, soil and animals; extraction of mites from soil, plants and stored products; preparation of mounting media and slide mounts; external morphology of mites; identification of mites up to family level using keys; studying different rearing techniques for mites.

Suggested Readings

- Chhillar BS, Gulati R & Bhatnagar P. 2007. Agricultural Acarology. Daya Publ. House, New Delhi.
- Gerson U & Smiley RL. 1990. Acarine Biocontrol Agents - An Illustrated Key and Manual. Chapman & Hall, NewYork.
- Gupta SK. 1985. Handbook of Plant Mites of India. Zoological Survey of India, Calcutta.
- Gwilyn O & Evans GO. 1998. Principles of Acarology. CABI, London.
- Jeppson LR, Keifer HH & Baker EW. 1975. Mites Injurious to Economic Plants. University of California Press, Berkeley.
- Krantz GW. 1970. A Manual of Acarology. Oregon State Univ. Book Stores, Corvallis, Oregon.
- Qiang Zhiang Z. 2003. Mites of Green Houses- Identification, Biology and Control. CABI, London.
- Sadana GL. 1997. False Spider Mites Infesting Crops in India. Kalyani Publ. House, New Delhi.
- Walter DE & Proctor HC. 1999. Mites- Ecology, Evolution and Behaviour. CABI, London.

ENT 516 : SOIL ARTHROPODS AND THEIR MANAGEMENT 1+1

Objective

To impart knowledge about the different groups of arthropods found in soil, interaction between the different groups, and role of soil arthropods in humus formation. Hands-on training in sampling and identification of different groups of soil arthropods.

Theory

UNIT I

Soil arthropods and their classification, habitats and their identification.

UNIT II

Estimation of populations; sampling and extraction methods.

UNIT III

Role of soil arthropods in detritus feeding, litter breakdown and humus formation. Soil arthropods as bio-indicators of habitat qualities. Effect of soil arthropod activity on soil properties.

UNIT IV

Harmful and beneficial soil arthropods and their management, interrelationship among arthropods and other soil invertebrates and soil microorganisms. Anthropogenic effects on soil arthropods.

Practical

Sampling, extraction methods and identification of various types of soil fauna; estimation and assessment of soil arthropod population; techniques and culturing soil invertebrates.

Suggested Readings

- Anderson JM & Ingram JSI. 1993. Tropical Soil Biology and Fertility: A Handbook of Methods. CABI, London.
- Dindal DL. 1990. Soil Biology Guide. A Wiley-InterScience Publ., John Wiley & Sons, New York.
- Pankhurst C, Dube B & Gupta, V. 1997. Biological Indicators of Soil Health. CSIRO, Australia.
- Veeresh GK & Rajagopal D.1988. Applied Soil Biology and Ecology. Oxford & IBH Publ., New Delhi.

ENT 517 : VERTEBRATE PEST MANAGEMENT 1+1

Objective

To impart knowledge on vertebrate pests like birds, rodents, mammals etc., of different crops, their biology, damage they cause and management strategies.

Theory

UNIT I

Vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals. Biology of beneficial birds.

UNIT II

Population dynamics and assessment, patterns of pest damage and assessment, roosting and nesting systems in birds.

UNIT III

Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods- Operational practices-baiting, bioassays (LD50 studies), equipments and educative programmes. Wild Life Protection Act(1972) and its amendments.

Practical

Identification of important rodent and other vertebrate pests of agriculture, food preference and hoarding, social behaviour, damage assessment, field survey, population estimation, control operation and preventive methods.

Suggested Readings

- Fitzwater WD & Prakash I. 1989. Handbook of Vertebrate Pest Control. ICAR, New Delhi.
- Prakash I & Ghosh PK.1997. Rodents in Indian Agriculture. Vol. I. State of Art Scientific Publ., Jodhpur.
- Prakash I & Ghosh RP.1987. Management of Rodent Pests. ICAR, New Delhi.
- Prater SH. 1971. The Book of Indian Animals. The Bombay Natural History Society, Bombay.
- Ali S. 1965. The Book of Indian Birds. The Bombay Natural History Society, Bombay.

ENT 518 TECHNIQUES IN PLANT PROTECTION 0+1

Objective

To acquaint the students with appropriate use of plant protection equipments and techniques related to microscopoy, computation, pest forecasting, electrophoresis etc.

Theory

UNIT I

Pest control equipments, principles, operation, maintenance, selection, application of pesticides and biocontrol agents, seed dressing, soaking, root-dip treatment, dusting, spraying, application through irrigation water.

UNIT II

Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers.

UNIT III

Use of light, transmission and scanning electron microscopy.

UNIT IV

Protein isolation from the pest and host plant and its quantification using ectrophotometer and molecular weight determination using SDS/PAGE.

UNIT V

Use of tissue culture techniques in plant protection. Computer application for predicting/forecasting pest attack and identification.

Suggested Readings

- Alford DV. 1999. A Textbook of Agricultural Entomology. Blackwell Science, London.
- Crampton JM & Eggleston P. 1992. Insect Molecular Science. Academic Press, London.

ENT 519 : COMMERCIAL ENTOMOLOGY 1+1

Objective

To familiarize the students with entrepreneurial opportunities in entomology, provide information on productive insects and their products, as well as insect pests of public health and veterinary importance and their management.

Theory

UNIT I

Bee keeping- General colony management during different seasons. Seasonal management. Managing colonies for honey production and pollination. Artificial queen rearing. Pests and diseases of honey bees. Bee poisoning. Production and marketing of quality honey and value added honey products. Establishment and maintenance of apiaries.

UNIT II

Study of different species of silkworms, characteristic features, moriculture, silk and its uses, pests and diseases of silkworms, rearing and management of silkworms. Lac insect- natural enemies and their management.

UNIT III

Economic and public health importance of insect pests in human habitation and habitats, biology, damage and control of mosquitoes, houseflies, bed bugs, ants, termites, cockroaches, flies, silverfish, head and body lice, carpet beetles, cloth moths, crickets, wasps, house dust mites, insect pests of cattle, poultry, pet animals and their anagement.

UNIT IV

Principles and methods of pest management in residential places and public buildings, insecticides for domestic use and their safety, pre- and postconstruction termite proofing of buildings, appliances for domestic pest control. Rodent control methods. Organic methods of domestic pest management.

Practical

Assessing pest status in dwellings (labs, canteen or hostel), implementation of pest control against flies, mosquitoes, bed bugs, cockroaches and rodents. Pre- and post-construction termite proofing methods, control of silverfishes in the library. Visit to poultry units and assessing pest status in poultries. Evaluation of commercially available domestic insect pest control products through bioassays. Identification of honey bee species, bee castes and special adaptations, identification and handling of bee-keeping equipments. Handling of honey bees-hive and frame inspection. Honey extraction and processing methods of hive products extraction. Preparation of bee-keeping projects for funding. Visit to bee nursery and

commercial apiaries. Silkworm rearing and management. Lac host and crop management technology and processing of lac. Products and bye-products of lac.

Suggested Readings

- Aruga H. 1994. Principles of Sericulture. Oxford & IBH, New Delhi.
- Atwal AS. 2006. The World of the Honey Bee. Kalyani Publ., New Delhi.
- Ganga G. 2003. Comprehensive Sericulture. Vol. II. Silkworm Rearing and Silk Reeling. Oxford & IBH, New Delhi.
- Partiban S & David BV. 2007. Management of Household Pests and Public Health Pests. Namratha Publ., Chennai.
- Singh S. 1975. Beekeeping in India. ICAR, New Delhi.

ENT 520/ PL.PATH 520 / NEMA 514 : PLANT QUARANTINE 2+0

Objective

To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

Theory

UNIT I

Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

UNIT II

Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, APEDA, Import and Export of bio-control agents.

UNIT III

Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestations /salvaging of infected material.

UNIT IV

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; Sanitary and Phytosanitary measures.

Suggested Readings

Rajeev K & Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.

Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

ENT 601 : ADVANCED INSECT SYSTEMATICS 1+2

Objective

To familiarize the students with different schools of classification, phylogenetics, classical and molecular methods, evolution of different groups of insects. International Code of Zoological Nomenclature. Ethics and procedure for taxonomic publications.

Theory

UNIT I

Detailed study of three schools of classification- numerical, evolutionary and cladistics. Methodologies employed. Development of phenograms, cladograms, molecular approaches for the classification of organisms. Methods in identification of homology. Species concepts and peciation processes and evidences. Zoogeography.

UNIT II

Study of different views on the evolution of insects- alternative phylogenies of insects: Kukalova Peck and Kristensen. Fossil insects and evolution of insect diversity over geological times.

UNIT III

Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN- Ethics.

UNIT IV

Concept of Phylocode and alternative naming systems for animals. A detailed study of selected representatives of taxonomic publications – small publications of species descriptions, revisionary works, monographs, check lists, faunal volumes, etc. Websites related to insect taxonomy and databases. Molecular Taxonomy, barcoding species.

Practical

Collection, curation and study of one taxon of insects- literature search, compilation of a checklist, study of characters, development of character table, construction of taxonomic keys for the selected group. Development of descriptions, photographing, writing , and preparation of specimens for "type like" preservation. Submission of the collections made of the group. Multivariate Analysis techniques for clustering specimens into different taxa, and development of phenograms. Rooting and character polarisation for developing cladograms and use of computer programmes to develop cladograms.

Suggested Readings

- CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I & II, CSIRO. Cornell Univ. Press, Ithaca.
- Dakeshott J & Whitten MA. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer-Verlag, Berlin.
- Freeman S & Herron JC. 1998. Evolutionary Analysis. Prentice Hall, New Delhi.
- Hennig W. 1960. Phylogenetic Systematics. Urbana Univ. Illinois Press, USA.
- Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2nd Ed. Academic Press, New York.
- Mayr E & Ashlock PD. 1991. Principles of Systematic Zoology. 2nd Ed. McGraw Hill, New York.
- Mayr E.1969. Principles of Systematic Zoology. McGraw-Hill, New York.
- Quicke DLJ. 1993. Principles and Techniques of Contemporary Taxonomy. Blackie Academic and Professional, London.
- Ross HH. 1974. Biological Systematics. Addison Wesley Publ. Co., London.
- Wiley EO. 1981. Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists. Columbia Univ. Press, USA.

ENT 602 : IMMATURE STAGES OF INSECTS 1+1

Objective

To impart knowledge on morphology of immature stages of different groups of insects. Train students in identification of common pest species during their immature stages.

Theory

UNIT I

Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of different immature stages of crop pests and stored product insects

UNIT II

Comparative study of life history strategies in hemi-metabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

Practical

Types of immature stages; their collection, rearing and preservation. Identification of immature insects to orders and families, in endopterygote orders viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using key.

Suggested Readings

- Chu HF. 1992. How to Know Immature Insects. William Brown Publ., Iowa.
- Peterson A. 1962. Larvae of Insects. Ohio University Press, Ohio.
- Stehr FW. 1998. Immature Insects. Vols. I, II. Kendall Hunt Publ., Iowa.

ENT 603 : ADVANCED INSECT PHYSIOLOGY 2+0

Objective

To impart knowledge to the students on detailed physiology of various secretory and excretory systems, moulting process, chitin synthesis, physiology of digestion, transmission of nerve impulses, nutrition of insects, pheromones etc.

Theory

UNIT I

Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, types of sclerotization.

UNIT II

Digestive enzymes, digestive physiology in phytophagous, wood boring and wool feeding insects, efficiency of digestion and absorption, role of endosymbionts in insect nutrition, nutritional effects on growth and development; physiology of excretion and osmoregulation, water conservation mechanisms.

UNIT III

Detailed physiology of nervous system, transmission of nerve impulses, neurotransmitters and modulators. Production of receptor potentials in different types of sensilla, pheromones and other semiochemicals in insect life, toxins and defense mechanisms.

UNIT IV

Endocrine system and insect hormones, physiology of insect growth and development-metamorphosis, polyphenism and diapause. Energetics of muscle contractions.

Suggested Readings

- Kerkut GA & Gilbert LI. 1985. Insect Physiology, Biochemistry and Pharmacology. Vols. I- XIII. Pergamon Press, Oxford, New York.
- Muraleedharan K. 1997. Recent Advances in Insect Endocrinology. Assoc. for Advancement of Entomology, Trivandrum, Kerala.

ENT 604 : ADVANCED INSECT ECOLOGY 1+1

Objective

To impart advanced practical knowledge of causal factors governing the distribution and abundance of insects and the evolution of ecological characteristics.

Theory

UNIT I

Characterisation of distribution of insects- Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics- Life tables, Leslie Matrix, Stable age distribution, Population projections. Predator-Prey Models- Lotka-Volterra and Nicholson-Bailey Model. Crop Modeling- an introduction.

UNIT II

Insect Plant Interactions. Fig-figwasp mutualism and a quantitative view of types of Associations. Role of insects in the environment. Adaptations to terrestrial habitats. Evolution of Insect diversity and role of phytophagy as an adaptive zone for increased diversity of insects. Evolution of resource harvesting organs, resilience of insect taxa and the sustenance of insect diversity- role of plants. Herbivory, pollination, predation, parasitism. Modes of insect-plant interaction, tri-trophic interactions. Evolution of herbivory, monophagy vs polyphagy. Role of plant secondary metabolites. Host seeking behaviour of parasitoids. Meaning of stress-plant stress and herbivory. Consequences of herbivory to plant fitness and response to stress. Constitutive and induced plant defenses.

UNIT III

Biodiversity and Conservation- RET species, Ecological Indicators. Principles of Population genetics, Hardy Weinberg Law, Computation of Allelic and Phenotypic frequencies, Fitness under selection, Rates of Evolution under selection. Foraging Ecology- Optimal foraging theory, Marginal Value Theorem, and Patch departure rules, central place foraging, Mean-variance relationship and foraging by pollinators, Nutritional Ecology.

UNIT IV

Reproductive ecology- Sexual selection, Mating systems, Reproductive strategies - timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict. Agro- ecological vs Natural Ecosystems – Characterisation, Pest Control as applied ecology- case studies.

Practical

Methods of data collection under field conditions. Assessment of distribution parameters, Taylor's power law, Iwao's patchiness index, Index of Dispersion, etc. Calculation of sample sizes by different methods. Fitting Poisson and Negative Binomial distributions and working out the data transformation methods. Hardy-Weinberg Law, Computation of Allelic and Phenotypic Frequencies - Calculation of changes under selection, Demonstration of genetic drift. Assessment of Patch Departure rules. Assessment of Resource size by female insects using a suitable insect model, fruit flies/*Goniozus*/Female Bruchids etc.- A test of reproductive effort and fitness. Construction of Life tables and application of Leslie Matrix – population projections, Stable age distribution. Exercises in development of Algorithms for crop modeling.

Suggested Readings

- Barbosa P & Letourneau DK. (Eds.). 1988. Novel Aspects of Insect-Plant Interactions. Wiley, London.
- Elizabeth BA & Chapman RF. 1994. Host-Plant Selection by Phytophagous Insects. Chapman & Hall, New York.
- Freeman S & Herron JC.1998. Evolutionary Analysis. Prentice Hall, New Delhi.
- Gotelli NJ & Ellison AM. 2004. A Primer of Ecological Statistics. Sinauer Associates, Sunderland, MA.
- Gotelli NJ. 2001. A Primer of Ecology. 3rd Ed., Sinauer Associates, Sunderland, MA, USA.
- Krebs C. 1998. Ecological Methodology. 2nd Ed. Benjamin-Cummings Publ. Co., New York.
- Krebs CJ. 2001 Ecology: The Experimental Analysis of Distribution and Abundance. 5th Ed. Benjamin-Cummings Publ. Co., New York.
- Magurran AE. 1988. Ecological Diversity and its Measurement. Princeton University Press, Princeton.
- Real LA & Brown JH. (Eds.). 1991. Foundations of Ecology: Classic Papers with Commentaries. University of Chicago Press, USA.
- Southwood TRE & Henderson PA. 2000. Ecological Methods. 3rd Ed. Wiley Blackwell, London.
- Strong DR, Lawton JH & Southwood R. 1984. Insects on Plants: Community Patterns and Mechanism. Harward University Press, Harward.
- Wratten SD & Fry GLA. 1980. Field and Laboratory Exercises in Ecology. Arnold Publ., London.

ENT 605 : INSECT BEHAVIOUR 1+1

Objective

To acquaint the students with a thorough understanding of how natural selection has led to various survival strategies manifested as behaviour in insects.

Theory

UNIT I

Defining Behaviour- Concept of umwelt, instinct, fixed action patterns, imprinting, complex behaviour, inducted behaviour, learnt behaviour and motivation. History of Ethology- development of behaviorism and ethology, contribution of Darwin, Frisch, Tinbergen and Lorenz; Studying behaviour- Proximate and Ultimate approaches, behavioural traits under natural selection, genetic control of behaviour and behavioural polymorphism.

UNIT II

Orientation- Forms of primary and secondary orientation including taxes and kinesis; Communication- primary and secondary orientation, responses to environmental stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals.

UNIT III

Reproductive behaviour- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behaviour- kin selection, parental manipulation and mutualism; Selforganization and insect behaviour.

UNIT IV

Foraging- Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behaviour, pollination behaviour, coevolution of plants and insect pollinators. Behaviour in IPM- Concept of super-normal stimuli and behavioural manipulation as potential tool in pest management, use of semio-chemicals, auditory stimuli and visual signals in pest management.

Practical

Quantitative methods in sampling behaviour; training bees to artificial feeders; sensory adaptation and habituation in a fly or butterfly model, physical cues used in host selection in a phytophagous insect, chemical and odour cues in host selection in phytophagous insect (DBM or gram pod borer), colour discrimination in honey bee or butterfly model, learning and memory in bees, role of self-organization in resource tracking by honeybees. Evaluation of different types of traps against fruit flies with respect to signals; Use of honey bees/*Helicoverpa armigera* to understand behavioural polymorphism with respect to learning and response to pheromone mixtures, respectively.

Suggested Readings

- Ananthkrishnan TN. (Ed.). 1994. Functional Dynamics of Phytophagous Insects. Oxford & IBH, New Delhi.
- Awasthi VB. 2001. Principles of Insect Behaviour. Scientific Publ., Jodhpur.
- Bernays EA & Chapman RF. 1994. Host-Plant Selection by Phytophagous Insects. Chapman & Hall, London.
- Brown LB. 1999. The Experimental Analysis of Insect Behaviour. Springer, Berlin.
- Krebs JR & Davies NB. 1993. An Introduction to Behavioural Ecology. 3rd Ed. Chapman & Hall, London.
- Manning A & Dawkins MS. 1992. An Introduction to Animal Behaviour. Cambridge University Press, USA.
- Mathews RW & Mathews JR. 1978. Insect Behaviour. A Wiley- InterScience Publ. John Wiley & Sons, New York.

ENT 606 : RECENT TRENDS IN BIOLOGICAL CONTROL 1+1

Objective

To appraise the students with advanced techniques in handling of different bioagents, modern methods of biological control and scope in cropping system-based pest management in agro-ecosystems.

Theory

UNIT I

Scope of classical biological control and augmentative biocontrol; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of biocontrol agents *vis-à-vis* target pest populations.

UNIT II

Mass culturing techniques, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices.

UNIT III

Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, large-scale production of biocontrol agents, bankable project preparation.

UNIT IV

Scope of genetically engineered microbes and parasitoids in biological control, genetics of ideal traits in biocontrol agents for introgressing and for progeny selections, breeding techniques of biocontrol agents.

Practical

Mass rearing and release of some commonly occurring indigenous natural enemies; assessment of role of natural enemies in reducing pest populations; testing side effects of pesticides on natural enemies; effect of semiochemicals on natural enemies, breeding of various biocontrol agents, performance of efficiency analyses on target pests; project document preparation for establishing a viable mass-production unit /insectary.

Suggested Readings

- Burges HD & Hussey NW. (Eds.). 1971. Microbial Control of Insects and Mites. Academic Press, London.
- Coppel HC & James WM. 1977. Biological Insect Pest Suppression. Springer Verlag, Berlin.
- De Bach P. 1964. Biological Control of Insect Pests and Weeds. Chapman & Hall, London.
- Dhaliwal, GS & Koul O. 2007. Biopesticides and Pest Management. Kalyani Publ., New Delhi.
- Gerson H & Smiley RL. 1990. Acarine Biocontrol Agents – An Illustrated Key and Manual. Chapman & Hall, New York.
- Huffakar CB & Messenger PS. 1976. Theory and Practices of Biological Control. Academic Press, London.

ENT 607 : ADVANCED INSECTICIDE TOXICOLOGY 2+1

Objective

To acquaint the students with the latest advancements in the field of insecticide toxicology, biochemical and physiological target sites of insecticides, and pesticide resistance mechanisms in insects.

Theory

UNIT I

Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides.

UNIT II

Biochemical and physiological target sites of insecticides in insects; developments in biorationals, biopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides.

UNIT III

Joint action of insecticides; activation, synergism and potentiation.

UNIT IV

Problems associated with pesticide use in agriculture: pesticide resistance resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; persistence and pollution; health hazards and other side effects.

UNIT V

Estimation of insecticidal residues- sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; good agricultural practices to minimize insecticidal hazards.

Practical

Sampling, extraction, clean-up and estimation of insecticide residues by various methods; calculations and interpretation of data; biochemical and biological techniques for detection of insecticide resistance in insects.

Suggested Readings

- Busvine JR. 1971. A Critical Review on the Techniques for Testing Insecticides. CABI, London.
- Dhaliwal GS & Koul O. 2007. Biopesticides and Pest Management. Kalyani Publ., New Delhi.
- Hayes WJ & Laws ER. 1991. Handbook of Pesticide Toxicology.Academic Press, New York.

- Ishaaya I & Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.
- Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York.
- O' Brien RD. 1974. Insecticides Action and Metabolism. Academic Press, New York.
- Perry AS, Yamamoto I, Ishaaya I & Perry R. 1998. Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi.
- Prakash A & Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publ., New York.

ENT 608 : ADVANCED HOST PLANT RESISTANCE 1+1

Objective

To familiarize the students with recent advances in resistance of plants to insects and acquaint with the techniques for assessment and evaluation of resistance in crop plants.

Theory

UNIT I

Importance of plant resistance, historical perspective, desirable morphological, anatomical and biochemical adaptations of resistance; assembly of plant species - gene pool; insect sources – behaviour in relation to host plant factors.

UNIT II

Physical and chemical environment conferring resistance in plants, role of trypsin inhibitors and protease inhibitors in plant resistance; biochemistry of induced resistance – signal transduction pathways, methyl jasmonate pathways, polyphenol oxidase pathways, salicylic acid pathways; effects of induced resistance; exogenous application of elicitors.

UNIT III

Biotechnological approaches in host plant resistance- genetic manipulation of secondary plant substances; incorporation of resistant gene in crop varieties; marker-aided selection in resistance breeding.

UNIT IV

Estimation of plant resistance based on plant damage- screening and damage rating; evaluation based on insect responses; techniques and determination of categories of plant resistance; breakdown of resistance in crop varieties.

Practical

Understanding mechanisms of resistance for orientation, feeding, oviposition *etc.*, allelochemical bases of insect resistance; macroculturing of test insects like aphids, leaf/plant hoppers, mites and stored grain pests; field screening- microplot techniques, infester row technique, spreader row technique and plant nurseries; determination of antixenosis index, antibiosis index, tolerance index, plant resistance index.

Suggested Readings

- Panda N. 1979. Principles of Host Plant Resistance to Insects. Allenheld, Osum & Co., New York.
- Rosenthal GA & Janzen DH. (Eds.). 1979. Herbivores – their Interactions with Secondary Plant Metabolites. Vol. I, II. Academic Press, New York.
- Sadasivam S & Thayumanavan B. 2003. Molecular Host Plant Resistance to Pests. Marcel Dekker, New York.
- Smith CM, Khan ZR & Pathak MD. 1994. Techniques for Evaluating Insect Resistance in Crop Plants. CRC Press, Boca Raton, Florida.

ENT 609 : ADVANCED ACAROLOGY 1+1

Objective

To acquire a good working knowledge of identification of economically important groups of mites up to the species level, a detailed understanding of the newer acaricide molecules and utilization of predators.

Theory

UNIT I

Comparative morphology of Acari, phylogeny of higher categories in mites, knowledge of commonly occurring orders and families of Acari in India. Diagnostic characteristics of

commonly occurring species from families Tetranychidae, Tenuipalpidae, Eriophyidae, Tarsonemidae, Phytoseiidae, Bdellidae, Cunaxidae, Stigmaeidae, Pymotidae, Cheyletidae, Acaridae, Pyroglyphidae, Orthogalumnidae, Argasidae, Ixodidae, Sarcoptidae. Soil mites in India.

UNIT II

Management of economical important species of mites in agriculture, veterinary and public health; storage acarology.

UNIT III

Mites as vectors of plant pathogens; mode of action, structure-activity relationships of different groups of acaricides; problem of pesticide resistance in mites, resurgence of mites.

UNIT IV

Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungi- identification, isolation and utilization.

Practical

Identification of commonly occurring mites up to species, preparation of keys for identification. Collection of specific groups of mites and preparing their identification keys. Rearing phytoseiid mites and studying their role in suppression of spider mites. Management of mite pests of crops using acaricides, phytoseiid predators, fungal pathogens *etc.*

Suggested Readings

- Evans GO.1992. Principles of Acarology. CABI, London.
- Gerson H & Smiley RL. 1990. Acarine Biocontrol Agents- An Illustrated Key and Manual. Chapman & Hall, New York.
- Gupta SK. 1985. Handbook of Plant Mites of India. Zoological Survey of India, Calcutta.
- Krantz GW. 1970. A Manual of Acarology. Oregon State University Book Stores, Corvallis, Oregon.
- Sadana GL. 1997. False Spider Mites Infesting Crops in India. Kalyani Publ. House, New Delhi.

ENT 610 : AGRICULTURAL ORNITHOLOGY 1+1

Objective

To expose the students to the prevalence of birds in agricultural fields, their habitat associations and the beneficial and harmful role played by birds in crop fields and management of pest situations.

Theory

UNIT I

Status of agricultural ornithology in India, groups of birds associated with agro-ecosystems. Habitat associations of birds in both wet and dry agricultural systems. Association of birds with different cultivation practices and crop stages, their seasonality and succession. Pestiferous and beneficial birds associated with different crops, their general biology and ecology. Food and feeding habits of birds in crop fields.

UNIT II

Nature of damage caused by birds in different crops. Foraging ecology of birds in agricultural fields. Birds affecting stored grains in houses and godowns. Beneficial role of birds in agriculture and attracting them to field. Use of bird excreta in agriculture. Management of bird pests in agriculture: physical, cultural, ecological and chemical methods. Wild Life Protection Act(1972).

Practical

Study of different groups of birds associated with agriculture, their morphology and field identification. Field visits to different agroecosystems. Study of bird associations with different crop stages. Study of nesting and roosting habits of birds in agricultural habitats. Study of the feeding habits, nature and types of damage caused by birds in selected crops. Visits to godowns. Analysis and study of the use of bird excreta in agriculture at a bird sanctuary. Field visits to paddy growing command areas to study birds in crop fields. Assignments on assessing bird damage, estimation of populations etc.

Suggested Readings

- Dhindsa SR & Parasharya BM. 1998. Birds in Agricultural Ecosystem. Society for Applied Ornithology, Hyderabad.
- Mehrotra KN & Bhatnagar RK. 1979. Status of Economic Ornithology in India- Bird Depredents, Depredations and their Management. ICAR, New Delhi.
- Vasudeva Rao & Dubey OP. 2006. Grainivorous Pests and their Management. In: Vertebrate Pests in Agriculture, The Indian Scenario (Ed: Sridhara, S.), Scientific Publ., Jodhpur.

ENT 611 : MOLECULAR APPROACHES IN ENTOMOLOGICAL RESEARCH 1+1

Objective

To familiarize the students with DNA recombitant techonology, marker genes, transgenic plants, biotechnology in sericulture and apiculture.

Theory

UNIT I

Introduction to molecular biology; techniques used in molecular biology.

UNIT II

DNA and RNA analysis in insects- transcription and translocation mechanisms. DNA recombinant technology, identification of genes/nucleotide sequences for characters of interest. Genetic improvement of natural enemies. Cell lines, genetic engineering in baculoviruses, *Bt* and entomopathogenic fungi.

UNIT III

Genes of interest in entomological research- marker genes for sex identification,
neuropeptides, JH esterase, St toxins and venoms, chitinase, CPTI; lectins and proteases. Peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Bt toxin, CPTI; trypsin inhibitors, lectins and proteases, neuropeptides. Transgenic plants for pest resistance and diseases.

UNIT IV

Insect gene transformation; biotechnology in relation to silkworms and honey bees; introduction of lectin genes for pest suppression; DNA finger printing for taxonomy and phylogeny. Genetic improvement of inebriate tolerance of natural enemies.

UNIT V

DNA-based diagnostics; insect immune systems in comparison to vertebrates; molecular basis of metamorphosis; Sf transgenic technology and implications; molecular biology of baculoviruses; insecticide resistance. Resistance management strategies in transgenic crops.

Practical

Isolation of DNA/RNA; purity determinations; base pair estimation; agarose gel electrophoresis; restriction mapping of DNA; demonstration of PCR, RFLP and RAPD techniques.

Suggested Readings

- Bhattacharya TK, Kumar P & Sharma A. 2007. Animal Biotehnology. 1st Ed., Kalyani Publ., New Delhi.
- Hagedon HH, Hilderbrand JG, Kidwell MG & Law JH. 1990. Molecular Insect Science. Plenum Press, New York.
- Oakeshott J & Whitten MA.. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer Verlag.
- Rechcigl JE & Rechcigl NA. 1998. Biological and Biotechnological Control of Insect Pests. Lewis Publ., North Carolina.
- Roy U & Saxena V. 2007. A Hand Book of Genetic Engineering. 1st Ed., Kalyani Publ., New Delhi.
- Singh BD. 2008. Biotechnology (Expanding Horizons). Kalyani Publ., New Delhi.
- Singh P. 2007. Introductory to Biotechnology. 2nd Ed. Kalyani Publ., New Delhi.

ENT 612 : ADVANCED INTEGRATED PEST MANAGEMENT 2+0

Objective

To acquaint the students with recent concepts of integrated pest management. Surviellance and data base management. Successful national and international case histories of integrated pest management, non conventional tools in pest management.

Theory

UNIT I

Principles of sampling and surveillance; database management and computer programming, simulation techniques and system analysis and modeling.

UNIT II

Case histories of national and international programmes, their implementation, adoption and criticisms, global trade and risk of invasive pests. Wilde Area Management of Insect Posts.

UNIT III

Genetic engineering and new technologies- their progress and limitations in IPM programmes, deployment of benevolent alien genes for pest management- case studies; scope and limitations of bio-intensive and ecological based IPM programmes. Application of IPM to farmers' real-time situations.

UNIT IV

Challenges, needs and future outlook; dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.

Suggested Readings

- Dhaliwal GS & Arora R. 2003. Integrated Pest Management – Concepts and Approaches. Kalyani Publ., New Delhi.
- Dhaliwal GS, Singh R & Chhillar BS. 2006. Essentials of Agricultural Entomology. Kalyani Publ., New Delhi.
- Flint MC & Bosch RV. 1981. Introduction to Integrated Pest Management. Springer, Berlin.
- Koul O & Cuperus GW. 2007. Ecologically Based Integrated Pest Management. CABI, London.
- Koul O, Dhaliwal GS & Curperus GW. 2004. Integrated Pest Management -Potential, Constraints and Challenges. CABI, London.
- Maredia KM, Dakouo D & Mota-Sanchez D. 2003. Integrated Pest Management in the Global Arena. CABI, London.
- Metcalf RL & Luckman WH. 1982. Introduction of Insect Pest Management. John Wiley & Sons, New York.
- Norris RF, Caswell-Chen EP & Kogan M. 2002. Concept in Integrated Pest Management.Prentice Hall, New Delhi.
- Pedigo RL. 1996. Entomology and Pest Management. Prentice Hall, New Delhi.
- Subramanyam B & Hagstrum DW. 1995. Integrated Management of Insects in Stored Products. Marcel Dekker, New York.

ENT 613/ PL PATH 606 : PLANT BIOSECURITY AND BIOSAFETY 2+0

Objective

To facilitate deeper understanding on plant biosecurity and biosafety issues in agriculture.

Theory

UNIT I

History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/resurgence of pests and diseases.

UNIT II

National Regulatory Mechanism and International Agreements/ Conventions viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information

System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

UNIT III

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops.

Suggested Readings

- FAO Biosecurity Toolkit 2008.www.fao.org/docrep/010/a1140e/a1140e00.htm
- Laboratory Biosecurity Guidance. http://www.who.int/csr/resources /publications/ biosafety/ WHO_CD S_EPR_2006.pdf
- Grotto Andrew J & Jonathan B Tucker. 2006. Biosecurity: A Comprehensive Action Plan. http://www.americanprogress.org/kf/biosecurity_a_comprehensive_ action_plan.pdf
- Biosecurity Australia. www.daff.gov.au/ba;www.affa.gov.au/biosecurityaustralia Biosecurity New Zealand. www.biosecurity.govt.nz
- DEFRA.www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
- Randhawa GJ, Khetarpal RK, Tyagi RK & Dhillon. BS (Eds.). 2001.
- Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.
- Khetarpal RK & Kavita Gupta 2006. Plant Biosecurity in India - Status and Strategy. Asian Biotechnology and Development Review 9(2): 39- 63.
- Biosecurity for Agriculture and Food Production. http://www.fao.org/biosecurity/
- CFIA.http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.sht ml

NEMATOLOGY

NEMA 501 : PRINCIPLES OF NEMATOLOGY 2+1

Objective

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

Theory

UNIT I

History and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

UNIT II

Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology.

UNIT III

Types of parasitism; nature of damage and general symptomatology;
interaction of plant parasitic nematodes with other organisms.

UNIT IV

Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.

UNIT V

Principles and practices of nematode management; integrated nematode management.

Practical

Studies on kinds of nematodes- free-living, animal, insect and plant parasites; nematode sampling and extraction from soil; extraction of migratory endoparasites, staining for sedentary endoparasites; examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology.

Suggested Readings

- Dropkin VH. 1980. *An Introduction to Plant Nematology*. John Wiley & Sons, New York.
- Perry RN & Moens M. 2006. *Plant Nematology*. CABI, London.
- Singh RS & Sitaramaiah K. 1994. *Plant Pathogens – Nematodes*. Oxford & IBH, New Delhi.
- Thorne G. 1961. *Principles of Nematology*. McGraw Hill, New Delhi.
- Walia RK & Bajaj HK. 2003. *Text Book on Introductory Plant Nematology*. ICAR, New Delhi.

NEM 502/ ENT 503 : PRINCIPLES OF TAXONOMY 2+0

Objective

To sensitize the students on the theory and practice of classifying organisms and the rules governing the same.

Theory

UNIT I

Introduction to history and principles of systematics and importance. Levels and functions of systematics. Identification, purpose, methods- character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy vs homology, parallel vs convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism.

UNIT II

Classification of animals: Schools of classification- Phenetics, Cladistics and Evolutionary classification. Components of Biological Classification: Hierarchy, Rank, Category and Taxon. Species concepts, cryptic, sibling and etho-species, infra-specific categories. Introduction to numerical, biological and cytogenetical taxonomy.

UNIT III

Nomenclature: Common vs Scientific names. International Code of Zoological Nomenclature, criteria for availability of names, validity of names. Categories of names under consideration of ICZN. Publications, Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature. Speciation, anagenesis vs cladogenesis, allopatric, sympatric and parapatric processes.

Suggested Readings

- Blackwelder RE. 1967. Taxonomy - A Text and Reference Book. John Wiley & Sons, New York.
- Kapoor VC. 1983. Theory and Practice in Animal Taxonomy. Oxford & IBH, New Delhi.
- Mayr E. 1971. Principles of Systematic Zoology. Tata McGraw-Hill, New Delhi.
- Quicke DLJ. 1993. Principles and Techniques of Contemporary Taxonomy. Blackie, London.

NEMA 503 : STRUCTURAL AND FUNCTIONAL ORGANIZATION OF NEMATODES 2+1

Objective

Familiarization with structural organization of nematode body so as to enable the students to understand biology, physiology and classification of nematodes.

Theory

UNIT I

Introduction and general organization of nematode body.

UNIT II

Morphology and anatomy of nematode cuticle, hypodermis, musculature and pseudocoelom.

UNIT III

Digestive system- structural variations of stoma, oesophagus, intestine and rectum in nematodes.

UNIT IV

Reproductive system- terminology and variations in female and male reproductive systems, nemic eggs and sperms, types of reproduction, spermatogenesis and oogenesis.

UNIT V

Types and structure of excretory-secretory systems; nervous system and associated sense organs.

Practical

Studies on variations in nematode shapes and sizes, morphological details of cuticle, cuticular markings and ornamentation, variations in stoma, oesophagus, rectum; types and parts of female and male reproductive systems, sense organs, and excretory system.

Suggested Readings

- Bird AF & Bird J. 1991. The Structure of Nematodes. Academic Press, New York.
- Chitwood BG & Chitwood MB. 1950. An Introduction to Nematology. Univ. Park Press, Baltimore.
- Maggenti AR. 1981. General Nematology. Springer-Verlag, New York.
- Malakhov VV. 1994. Nematodes: Structure, Development, Classification and Phylogeny. Smithsonian Institution Press, Washington DC.

NEMA 504 : CLASSIFICATION OF NEMATODES 2+1

Objective

Development of skills in the identification of plant parasitic nematodes up to genera and species levels.

Theory

UNIT I

Principles of nematode systematics.

UNIT II

Placement of nematodes in Animal Kingdom and comparison with related organisms.

UNIT III

Classification of Phylum Nematoda- Orders of Class Adenophorea and Secernentea; Diagnosis of Order Tylenchida- Suborder Tylenchina, Hoplolaimina and Criconematina; Infraorders Tylenchata and Anguinata- their families and genera.

UNIT IV

Diagnosis of genera and families of Suborders Hoplolaimina and Criconematina.

UNIT V

Orders Aphelenchida, Dorylaimida, Enoplida, Rhabditida with emphasis on economically important taxa.

Practical

Identification of common plant parasitic nematodes belonging to Orders Tylenchida, Dorylaimida, Aphelenchida and Enoplida up to generic level; and up to species level for major nematode pests (root-knot, cyst nematodes etc.) of crops. Identification of EPNs belonging to Order Rhabditida.

Suggested Readings

- DeCramer W. 1995. The Family Trichodoridae: Stubby Root and Virus Vector Nematodes. Kluwer Academic Press, Dordrecht.
- Geraert E. 2006. Tylenchida. Brill.
- Hunt DJ. 1993. Aphelenchida, Longidoridae and Trichodoridae – their Systematics and Bionomics. CABI, Wallingford.
- Siddiqi MR. 2000. Tylenchida: Parasites of Plants and Insects. 2nd Ed. CABI, Wallingford.

NEMA 505 : NEMATOLOGICAL TECHNIQUES 1+2

Objective

Understanding the principles, theoretical aspects and developing skills in nematological techniques.

Theory

UNIT I

Principles and use of light, scanning and transmission electron microscopes, and other laboratory equipments.

UNIT II

Survey and surveillance methods; collection of soil and plant samples; techniques for extraction of nematodes from soil and plant material; estimation of population densities.

UNIT III

Killing, fixing, clearing and mounting nematodes; measurements, preparation of perineal patterns, vulval cones of cyst nematodes, en-face views and body section of nematodes.

UNIT IV

In vitro and *in vivo* culturing techniques of plant parasitic, bacteriophagous, mycophagus and omnivorous nematodes.

UNIT V

Staining nematodes in plant tissues; microtomy for histopathological studies; collection of plant root exudates and their bioassay; preparation of plant materials for exhibition.

UNIT VI

Application of molecular techniques in Nematology.

Practical

Collection of soil and plant samples; extraction of nematodes from soil by Baermann funnel, sieving and decanting, elutriation and sugar centrifugal methods; extraction of cysts from soil; extraction of nematodes from plant material; estimation of population densities; staining plant material for nematodes; killing and fixing nematodes, clearing nematodes by slow and Seinhorst's methods; preparation of temporary and permanent mounts; measurements, drawing, microphotography, special preparation of nematodes - perineal patterns, vulval cones, en-face and body sections; collection of root exudates, preparation of exhibits of nematode diseased plant material, *in vitro* culturing techniques of nematodes- callous culture, excised root and carrot disc techniques.

Suggested Readings

- Ayoub SM. 1981. Plant Nematology – An Agricultural Training Aid. Nema Aid Publications.
- Barker KR, Carter CC & Sasser JN 1985. An Advanced Treatise on Meloidogyne. Vol. II. Methodology. International Meloidogyne Project, NCSU, Raliegh.
- Southey JF. 1986. Laboratory Methods for Work with Plant and Soil Nematodes. HMSO, London.
- Zuckerman BM, Mai WF & Harrison MB. 1985. Plant Nematology Laboratory Manual. Univ. of Massachusetts.

EMA 506 : NEMATODE DISEASES OF CROPS 3+1

Objective

To impart basic knowledge about the causal organism, nature of damage, symptoms and control of nematode diseases of agricultural and horticultural crops.

Theory

Diagnosis of causal organism, distribution, host range, biology and life cycle, nature of damage, symptoms, interaction with other organisms, and management of nematode diseases in different crops.

UNIT I

Cereal crops- Ear-cockle and tundu diseases of wheat, molya disease of wheat and barley; rice root nematode, rice root-knot and cyst nematode problems, ufra and white tip diseases of rice; lesion nematodes, cyst nematodes of maize and sorghum.

UNIT II

Pulses, Sugar, Fibre, Cash crops (Tobacco, Fennel), Fodder and Oilseed crops- Pigeon pea cyst nematode, root knot nematode, reniform nematode, lesion, lance nematode, sugarbeet cyst and soybean cyst nematode problems.

UNIT III

Vegetable crops- root-knot disease, reniform nematode, potato cyst nematode; stem and bulb nematode. Nematode problems of protected cultivation.

UNIT IV

Fruit crops- root-knot disease, reniform nematode, slow decline of citrus. Mushroom-nematode problems.

UNIT V

Plantation, medicinal and aromatic crops- burrowing nematode problem of banana, spices and condiments, root-knot and lesion nematode problems of coffee and tea, red ring disease of coconut. Forests- Pine wilt disease.

Practical

Diagnosis of causal organisms; identification of different life cycle stages; study of symptoms and histopathology of nematode damage in different crops, study tours for field diagnosis of nematode problems.

Suggested Readings

- Bhatti DS & Walia RK. 1992. Nematode Pests of Crops. CBS, New Delhi.
- Evans AAF, Trudgill DL & Webster JM. 1994. Plant Parasitic Nematodes in Temperate Agriculture. CABI, Wallingford.
- Luc M, Sikora RA & Bridge J. 2005. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. CABI, Wallingford.
- Nickle WR. 1991. Manual of Agricultural Nematology. Marcel Dekker, New York.
- Perry RN & Moens M. 2006. *Plant Nematology*. CABI, Wallingford.

NEMA 507 : NEMATODE BIOLOGY AND PHYSIOLOGY 2+1

Objective

To develop understanding of life cycle patterns, feeding and metabolic processes in phytonematodes which have implications in their management.

Theory

UNIT I

Host finding and invasion, feeding, hatching, moulting; life cycle patterns in different types of nematodes.

UNIT II

Types of reproduction, gametogenesis, embryogenesis and post embryogenesis.

UNIT III

Chemical composition of nematodes, hydrolytic enzymes, pseudocoelome and function of transport.

UNIT IV

Physiology of digestive system, intermediary metabolism.

UNIT V

Osmoregulation, physiology of excretory-secretory and neuromuscular systems.

Practical

Studies on embryogenesis and post-embryogenesis, hatching, moulting, life cycle development, feeding, enzymatic assay by electrophoresis.

Suggested Readings

- Croll NA. 1970. The Behaviour of Nematodes: The Activity, Senses and Responses. Edward Arnold, London.
- Croll NA & Mathews BE. 1977. Biology of Nematodes. Blackie, Glasgow.
- Lee DL. 2002. The Biology of Nematodes. Taylor & Francis, London.
- Lee DL & Atkinson H J. 1976. Physiology of Nematodes. MacMillan, London.
- Perry RN & Wright DJ. 1998. The Physiology and Biochemistry of Free-living and Plant Parasitic Nematodes. CABI, Wallingford.
- Wallace HR. 1963. *The Biology of Plant Parasitic Nematodes*. Edward Arnold, London.

NEMA 508 : NEMATODE ECOLOGY 2+1

Objective

To understand the life of plant parasitic nematodes in their environment; their survival strategies, and how to exploit these for their control.

Theory

UNIT I

Definition and scope; components of environment; evolution of nematodes; ecological classification, prevalence, distribution and dispersal of nematodes.

UNIT II

Role of nematodes in the food web; habitat and niche characteristics; community analysis and population estimation models.

UNIT III

Effects of abiotic and biotic factors on nematodes.

UNIT IV

Environmental extremes and nematode behaviour- aggregation, swarming, orientation, feeding and reproduction.

UNIT IV

Survival strategies of nematodes in adverse environment and absence of host.

UNIT V

Modeling population dynamics and relations with crop performance; ecological considerations in nematode management, data interpretation and systems simulation.

Practical

Study of nematode fauna in varied agro-ecological systems, community analysis of nematode populations, laboratory exercises on influence of abiotic factors on movement and hatching, green-house experiments on effect of abiotic factors on nematode populations and plant growth.

Suggested Readings

- Croll NA. 1970. The Behaviour of Nematodes: The Activity, Senses and Responses. Edward Arnold, London.
- Croll NA & Mathews BE. 1977. Biology of Nematodes. Blackie, Glasgow.
- Lee DL. 2002. The Biology of Nematodes. Taylor & Francis, London.
- Norton DC. 1978. Ecology of Plant Parasitic Nematodes. John Wiley.
- Poinar G. 1983. Natural History of Nematodes. Prentice Hall, Englewood Cliffs.
- Wallace HR. *1973. Nematode Ecology and Plant Disease. Edward Arnold, London.*

NEMA 509 : NEMATODE INTERACTIONS WITH OTHER ORGANISMS **2+1**

Objective

To understand the role of nematodes in disease complexes involving fungal, bacterial, viral and other organisms.

Theory

UNIT I

Concept of interaction and its importance in disease complexes and their management involving nematode and other organisms.

UNIT II

Interaction of plant parasitic nematodes with wilt causing fungal pathogens.

UNIT III

Interaction of plant parasitic nematodes with root rot and other fungal pathogens.

UNIT IV

Interaction of plant parasitic nematodes with bacterial pathogens, other nematode species and arthropods.

UNIT V

Virus transmission by nematodes.

Practical

Green-house experiments to study the role of plant parasitic nematodes in wilt/rot causing fungal and bacterial pathogens.

Suggested Readings

- Khan MW. 1993. Nemic Interactions. Chapman & Hall, New York.
- Lamberti F, Taylor CE & Seinhorst JW. 1975. Nematode Vectors of Plant Viruses. Plenum Press, London.
- Sasser JN & Jenkins WR. 1960. Nematology: Fundamentals and Recent Advances with Emphasis *on Plant Parasitic and Soil Forms*. Eurasia Publ. House, New Delhi.

NEMA 510 : NEMATODE MANAGEMENT 2+1

Objective

To impart comprehensive knowledge about the principles and practices of nematode management.

Theory

UNIT I

Concepts and history of nematode management; crop loss estimation, ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis.

UNIT II

Chemical methods- nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use.

UNIT III

Cultural practices- crop rotations and cropping sequences, fallowing, flooding, soil solarisation, rabbing, time of sowing, organic amendments of soil, bio- fumigation, antagonistic and trap crops, sanitation etc.

Physical methods- use of heat, hot water treatment and other methods of disinfestations of planting material.

UNIT IV

Biological methods- concepts and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use; phytotherapeutic methods – use of antagonistic plants and antinemic plant products.

UNIT V

Genetic methods- plant resistance; legal methods- quarantine regulations; integrated nematode management- concepts and applications.

Practical

In vitro screening of synthetic chemicals and plant products for nematicidal activity, and their application methods; methods for screening of crop germplasm for resistance against nematodes, laboratory exercises on biocontrol potential of fungal, bacterial parasites, and predacious fungi and nematodes.

Suggested Readings

- Bhatti DS & Walia RK. 1994. Nematode Pest Management in Crops. CBS, New Delhi.
- Brown GL. 1977. The Nemtode Destroying Fungi. CBP, Guelph.
- Brown RH & Kerry BR. 1987. Principles and Practice of Nematode Control in Crops. Academic Press, Sydney.
- Chen ZX, Chen SY& Dickson DW. 2004. Nematology: Advances and Perpectives. Vol. II: Nematode Management and Utilization. CABI, Wallingford.
- Perry RN & Moens M. 2006. Plant Nematology. CABI, Wallingford.
- Starr JL, Cook R & Bridge J. 2002. Plant Resistance to Parasitic Nematodes. CABI, Wallingford.
- Whitehead AG. 1997. *Plant Nematode Control*. CABI, Wallingford.

NEMA 511 : BENEFICIAL NEMATODES 1+1

Objective

To sensitize about the use of nematodes for the biological control of insect pests of crops, and application of some nematodes as biological models and as indicators of environmental pollution.

Theory

UNIT I

Beneficial nematode fauna- predators, parasites of insects, molluscs and other pests; Entomophilic nematodes- important groups, types of nematode- insect associations; taxonomic characteristics of nematode parasites of insects.

UNIT II

Host-parasite relations and life cycle of mermithids, entaphelenchids, thelastomids, sphaerularids and tylenchids.

UNIT III

Entomopathogenic nematodes- *Steinernema* and *Heterorhabditis,* their morphological characteristics, taxonomic status, biology and mode of action.

UNIT IV

Entomopathogenic nematodes- mass multiplication techniques, formulations, field applications and efficacy, success stories.

UNIT V

Nematodes as biological models, nematodes as indicators of pollution, role of nematodes in organic matter recycling.

Practical

Isolation, identification, mass rearing and application methods of entomopathogenic nematodes.

Suggested Readings

- Gaugler R & Kaya HK. 1990. Entomopathogenic Nematodes in Biological Control. CRC Press, Boca Raton, Florida.
- Gaugler R. 2002. Entomophilic Nematology. CABI, Wallingford.
- Grewal PS, Ehlars RU & Shapiro DI. 2005. Nematodes as Biocontrol Agents. CABI, Wallingford.
- Jairajpuri MS & Khan MS. 1982. Predatory Nematodes (Mononchida).Associated Publ. Co., New Delhi.
- Wood WB. 1998. The Nematode Caenorhabditis elegans. Cold Spring Harbor Press.
- Woodring JL & Kaya HK. 1988. Steinernematid and Heterorhabditid Nematodes: A Handbook of Techniques. Southern Coop. Bull., Ark. Ag. Ext. Sta.
- Zuckerman BM. (Ed.). 1980. Nematodes as Biological Models. Vols. I, II. Academic Press, New York. www2.oardc.ohio-state.edu/nematodes

NEMA 512/ ENT 510 : PRINCIPLES OF INTEGRATED PEST MANAGEMENT 1+1

Objective

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM. Train students in computation of ETL, implementing IPM programmes.

Theory

UNIT I

History and origin, definition and evolution of various related terminologies.

UNIT II

Concept and philosophy, ecological principles, economic threshold concept, and economic consideration.

UNIT III

Tools of pest management and their integration- legislative, cultural, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

Practical

Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment- direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system.

Suggested Readings

- Dhaliwal GS & Arora R. 2003. Integrated Pest Management – Concepts and Approaches. Kalyani Publ., New Delhi.
- Dhaliwal GS, Ram Singh & Chhillar BS. 2006. Essentials of Agricultural Entomology. Kalyani Publ., New Delhi.
- Flint MC & Bosch RV. 1981. Introduction to Integrated Pest Management. 1st Ed., Springer, New York.
- Horowitz AR & Ishaaya I. 2004. Insect Pest Management: Field and Protected Crops. Springer, New Delhi.
- Ignacimuthu SS & Jayaraj S. 2007. Biotechnology and Insect Pest Management. Elite Publ., New Delhi.
- Metcalf RL & Luckman WH. 1982. Introduction of Insect Pest Management. John Wiley & Sons, New York.
- Pedigo RL. 2002. Entomology and Pest Management. 4th Ed. Prentice Hall, New Delhi.
- Norris RF, Caswell-Chen EP & Kogan M. 2002. Concepts in Integrated Pest Management. Prentice Hall, New Delhi.
- Subramanyam B & Hagstrum DW. 1995. Integrated Management of Insects in Stored Products. Marcel Dekker, New York.

NEMA 513/ PL PATH 513 : DISEASE RESISTANCE IN PLANTS 2+0

Objective

To acquaint with disease resistance mechanisms in plants.

Theory

UNIT I

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminology.

UNIT II

Disease escapes, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

UNIT III

Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms.

UNIT IV

Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

Suggested Readings

- Dallice M et al.1996. Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction. APS, St Paul, Minnesota.
- Deverall BJ. 1977. Defence Mechanisms in Plants. Cambridge Univ. Press, Cambridge, New York.
- Parker J. 2008. Molecular Aspects of Plant Diseases Resistance. Blackwell Publ.
- Robinson RA. 1976. Plant Pathosystems. Springer Verlag, New York.
- Singh BD. 2005. Plant Breeding – Principles and Methods. 7th Ed. Kalyani Publ., Ludhiana.
- Van der Plank JE. 1975. Principles of Plant Infection. Academic Press, New York.
- Van der Plank JE. 1978. Genetic and Molecular Basis of Plant Pathogenesis. Springer Verlag, New York.
- Van der Plank JE. 1982. Host Pathogen Interactions in Plant Disease. Academic Press, New York.
- Van der Plank JE. 1984. Disease Resistance in Plants. Academic Press, New York.

NEM 514 / ENT 520 : PLANT QUARANTINE 2+0

Objective

To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

Theory

UNIT I

Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

UNIT II

Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and
Export of bio-control agents.

UNIT III

Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestation/salvaging of infected material.

UNIT IV

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Suggested Readings

- Rajeev K & Mukherjee RC. 1996. Role of Plant Quarantine in IPM. Aditya Books.
- Rhower GG. 1991. Regulatory Plant Pest Management. In: Handbook of Pest Management in Agriculture. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

NEMA 601 : ADVANCES IN STRUCTURE AND SYSTEMATICS OF NEMATODES 2+1

Objective

Studies on the ultrastructure of plant parasitic nematodes based on TEM and SEM, and appraisal of recent developments in their classification.

Theory

UNIT I

Ultrastructure of nematode body wall- cuticle, hypodermis and muscles; nematode feeding apparatus, and other parts of alimentary canal.

UNIT II

Ultrastructure of nematode sense organs, reproductive and excretory-secretory systems.

UNIT III

Principles and rules of nomenclature and classification; preparation of illustrations, keys and compendia for nematode species and other taxa.

UNIT IV

Non-conventional approaches of nematode identification- molecular, biochemical, immunodiagnostic, molecular characterization and DNA finger-printing techniques.

UNIT V

Development of computer-based nematode identification programmes.

Practical

Detailed studies of morphological structures and identification of plant parasitic nematodes up to species level. Drawing and measurements of nematodes, preparation of compendia and keys. Identification of species/races of root-knot and cyst nematodes using PAGE.

Suggested Readings

- Barrington EJW. 1967. Invertebrate Structure and Function. Nelson, Nairobi.
- Blackwelder RE. 1967. Taxonomy - A Text and Reference Book. John Wiley & Sons, New York.

- Chen ZX, Chen SY & Dickson DW. 2004. Nematology: Advances and Perspectives. Vol. I. Nematode Morphology, Physiology and Ecology. CABI, Wallingford.
- Geraert E. 2006. Nematology Monographs and Perspectives. Vol. IV. Brill.
- International Commission of Zoological Nomenclature 1999. International Code of Zoological Nomenclature 4th Ed. The Natural History Museum, London.
- Kapoor VC. 1983. Theory and Practice in Animal Taxonomy. Oxford & IBH, New Delhi.
- Mayr E. 1969. Principles of Systematic Zoology. Tata McGraw-Hill, New Delhi.
- Quicke DLJ. 1993. *Principles and Techniques of Contemporary Taxonomy*. Blackie, London.

NEMA 602 : CURRENT TOPICS IN NEMATODE DISEASE DEVELOPMENT AND HOST RESISTANCE 2+1

Objective

To update knowledge on the recent research trends in the field of plant nematode relationships at genetic and molecular level.

Theory

UNIT I

Mechanisms of pathogenesis, cytological and biochemical changes induced by nematode feeding.

UNIT II

Plant defense systems, role of phytoalexins etc. against major plant parasitic nematodes.

UNIT III

Genetic basis of plant resistance to nematodes and identification of resistance genes against economically important nematodes.

UNIT IV

Application of biotechnological methods in the development of nematode resistant crop cultivars; resistance markers; incorporation of resistance by conventional breeding and transgenic approaches.

UNIT V

Influence of microorganisms on plant nematode interactions.

Practical

Microtomy for study of histopathological changes induced by important nematodes, screening techniques for assessment of resistance in crop germplasm against nematodes.

Suggested Readings

- Barker KR, Pederson GA & Windham GL. 1998. Plant and Nematode Interactions. CABI, Wallingford.
- Fenoll C, Grundler FMW & Ohl SA. 1997. Cellular and Molecular aspects of Plant-Nematode Relationships. Kluwer Academic Press, Dordrecht.
- Lamberti F, Giorgi C & Bird D. 1994. *Advances in Molecular Plant Nematology*. Plenum Press.

NEMA 603 : ADVANCES IN NEMATODE MANAGEMENT 2+1

Objective

To keep abreast with latest developments and trends in nematode management.

Theory

UNIT I

Isolation, identification, host specificity, mode of action, culturing and field application potential of promising bio-control agents- predacious and parasitic fungi; nematoxic fungal culture filtrates.

UNIT II

Isolation, identification, host specificity, mode of action, culturing and field application potential of promising bio-control agents- parasitic and nematode antagonistic bacteria; predacious mites and predacious nematodes.

UNIT III

Mass culturing, formulation, quality control, bio-safety and registration protocols of bio-control agents.

UNIT IV

Phytoalexins, allelochemicals, phytotherapeutic substances, novel nematicides, deployment of resistant varieties and non-host crops in nematode suppressive cropping systems, emergence of resistance breaking biotypes, recent regulatory provisions and methods, quarantine and disinfection.

UNIT V

Nematode management modules for integrated pest and disease management in cropping systems. Nematode management options and approaches for organic farming and precision farming. Application of GIS and GPS technology for surveillance and management.

Practical

Green-house experiments on the efficacy of fungal and bacterial bio-control agents, botanicals.

Suggested Readings

- Chen ZX, Chen SY & Dickson DW. 2004. Nematology: Advances and Perspectives Vol. II. Nematode Management and Utilization. CABI, Wallingford.
- Jana BL. 2008. Precision Farming. Reseachco Books & Periodicals Pvt. Ltd., Delhi.
- Lillesend TW, Kiefer RW & Chipman JW. 1979. Remote Sensing and Image Interpretation. John Wiley & Sons, New York.
- Poinar GO Jr & Jansson H-B. 1988. Diseases of Nematodes. Vols. I, II. CRC Press, Boca Raton, Florida.
- Starr JR, Cook R & Bridge J. 2002. Plant Resistance to Parasitic Nematodes. CABI, Wallingford.
- Tarafdar JC, Priputhi KP & Mahesh Kumar 2007. Organic Agriculture. Scientific Publ., Jodhpur.
- Upadhyaya RK, Walia RK & Dubey OP. 2004. IPM Systems in Agriculture. Vol. IX. Phytonematology. Aditya Books, New Delhi.

NEMA 604 : PHYSIOLOGICAL AND MOLECULAR NEMATOLOGY 2+1

Objective

Appraisal on the application of modern biotechnological tools in Nematology.

Theory

UNIT I

Cell biology- Structural and functional aspects; genetics and evolution in plant parasitism in nematodes.

UNIT II

Caenorhabditis elegans- a model system for gerontology, cytogenetics, physiology, nutritional, toxicological and pharmacological studies; *Heterodera glycines* as a model for biology, proteomic and genomic studies.

UNIT III

Chemoreception, neurobiology, and biochemical basis of communication in nematodes, molecular basis of host recognition.

UNIT IV

Biochemical, genetical and molecular basis of plant nematode interaction; histopathological, cellular and molecular changes in host feeding cells, resistance genes and RNAi technology.

UNIT V

Biochemical and molecular basis of survival strategies in nematodes, molecular mechanism of host resistance against plant parasitic nematodes, molecular and novel approaches for nematode management.

Practical

Isolation and quantification of proteins from nematode juveniles and eggs; molecular weight determination ofnematode protein; β-esterase polymorphism in root-knot nematode; nematode DNA isolation from juveniles and eggs; RFLP of nematode DNA; nematode DNA amplification using PCR for nematode identification, RNAi technology.

Suggested Readings

- Chen ZX, Chen SY & Dickson DW. 2004. Nematology: Advances and Perspectives. Vol. I. Nematode Morphology, Physiology and Ecology. CABI, Wallingford.

- Fenoll C, Grundler FMW & Ohl SA. 1997. Cellular and Molecular aspects of Plant-Nematode Relationships. Kluwer Academic Publ., Dordrecht.
- Gommers EJ & Maas PW. 1992. Nematology from Molecule to Ecosystem. European Soc. of Nematologists.
- Lamberti F, Giorgi C. & Bird D. 1994. Advances in Molecular Plant Nematology. Plenum Press.
- Perry RN & Wright DJ. 1998. The Physiology and Biochemistry of Free- living and Plant Parasitic Nematodes. CABI, London.
- Riddle DL. 1997. C. elegans II. Cold Spring Harbor Press.
- Wood WB. 1988. The Nematode Caenorhabditis elegans. Cold Spring Harbor Press.
- Zuckerman BM. 1980. Nematodes as Biological Models. Vols. I, II. Academic Press, New York.

NEMA 605/ PL PATH 606 : PLANT BIOSECURITY AND BIOSAFETY 2+0

Objective

To facilitate deeper understanding on plant biosecurity and biosafety issues in agriculture.

Theory

UNIT I

History of biosecurity, concept of biosecurity, components of biosecurity, Quarantine, Invasive Alien Species, biowarfare, emerging/resurgence of pests and diseases.

UNIT II

National Regulatory Mechanism and International Agreements/Conventions viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

UNIT III

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops.

Suggested Readings

- FAO Biosecurity Toolkit 2008. www.fao.org/docrep/010/a1140e/a1140e00.htm
- Laboratory Biosecurity Guidance. http://www.who.int/csr/resources/publications/biosafety /WHO _ CD S_EPR_2006.pdf
- Grotto Andrew J & Jonathan B Tucker. 2006. Biosecurity: A Comprehensive Action Plan. http://www.americanprogress.org/kf/biosecurity_a_comprehensive_ action_plan.pdf
- Biosecurity Australia. www.daff.gov.au/ba;www.affa.gov.au/biosecurityaustralia
- Biosecurity New Zealand. www.biosecurity.govt.nz
- DEFRA. www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
- Randhawa GJ, Khetarpal RK, Tyagi RK & Dhillon. BS (Eds.). 2001.Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.
- Khetarpal RK & Kavita Gupta 2006. Plant Biosecurity in India - Status and Strategy. Asian Biotechnology and Development Review 9(2): 39-63.
- Biosecurity for Agriculture and Food Production.http://www.fao.org/biosecurity/
- CFIA. http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.shtml

PLANT PATHOLOGY

PL PATH 501 : MYCOLOGY 2+1

Objective

To study the nomenclature, classification and characters of fungi.

Theory

UNIT I

Introduction, definition of different terms, basic concepts. Identification of fungi.

UNIT II

Importance of mycology in agriculture, relation of fungi to human affairs, history of mycology.

UNIT III

Concepts of nomenclature and classification, fungal biodiversity, reproduction in fungi.

UNIT IV

The comparative morphology, ultrastructure, characters of different groups of fungi according to Alexopoulos *et al*.(2000), Protista: i.Myxomycota ii. Plasmodiophoromycota, Stramenopila: i. Oomycota ii. Hyphochytridiomycota, Fungi: i. Chytridiomycota ii. Zygomycota, iii. Ascomycota, iv. Basidiomycota, Lichens types and importance, fungal genetics and variability in fungi.

Practical

Detailed comparative study of different groups of fungi; collection, identification and preservation of specimens. Isolation and identification of plant pathogenic fungi.

Suggested Readings

- Ainsworth GC, Sparrow FK & Susman HS. 1973. The Fungi - An Advanced Treatise. Vol. IV (A & B). Academic Press, New York.
- Alexopoulos CJ, Mims CW & Blackwell M.2000. Introductory Mycology. 5th Ed. John Wiley & Sons, New York.
- Mehrotra RS & Arneja KR. 1990. An Introductory Mycology. Wiley Eastern, New Delhi.
- Sarbhoy AK. 2000. Text book of Mycology. ICAR, New Delhi.
- Singh RS. 1982. Plant Pathogens - The Fungi. Oxford & IBH, New Delhi.
- Tripathi, DP. 2006. Introductory Mycology. Kalyani Publishers. New Delhi.
- Webster J. 1980. Introduction to Fungi. 2nd Ed. Cambridge Univ. Press, Cambridge, New York.

PL PATH 502 : PLANT VIROLOGY 2+ 1

Objective

To acquaint with the structure, virus-vector relationship, biology and management of plant viruses.

Theory

UNIT I

History of plant viruses, Economic importance, composition and structure of viruses.

UNIT II

Symptomatology of important plant viral diseases, transmission, chemical and physical properties, host virus interaction, virus vector relationship.

UNIT III

Physiology of virus infected plant, Ecology, Virus nomenclature and classification, genome organization, replication and movement of viruses. Epidemiology of viral diseases.

UNIT IV

Isolation and purification, electron microscopy, protein and nucleic acid based diagnostics.

UNIT V

Mycoviruses, phytoplasma arbo and baculoviruses, satellite viruses, satellite RNAs, phages, viroids, prions. Principles of the working of electron-microscope and ultra-microtome.

UNIT VI

Origin and evolution, mechanism of resistance, genetic engineering, ecology, and management of plant viruses.

Practical

Study of symptoms caused by viruses, transmission, assay of viruses, physical properties, purification, method of raising antisera, serological tests, electron microscopy and ultratomy, PCR.

Suggested Readings

- Bos L. 1964. Symptoms of Virus Diseases in Plants. Oxford & IBH., New Delhi.
- Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ & Watson L. 1995. Virus of Plants: Descriptions and Lists from VIDE Database. CABI, Wallington.
- Gibbs A & Harrison B. 1976. Plant Virology - The Principles. Edward Arnold, London.
- Hull R. 2002. Mathew's Plant Virology. 4th Ed. Academic Press, New York.
- Noordam D. 1973. Identification of Plant Viruses, Methods and Experiments. Oxford & IBH, New Delhi.

PL PATH 503 : PLANT BACTERIOLOGY 2+1

Objective

To acquaint with plant pathogenic prokaryote (procarya) and their structure, nutritional requirements, survival and dissemination.

Theory

UNIT I

History and introduction to phytopathogenic procarya, viz., bacteria, MLOs, spiroplasmas and other fastidious procarya. Importance of phytopathogenic bacteria.

UNIT II

Evolution, classification and nomenclature of phytopathogenic procarya and important diseases caused by them. Microscopy.

UNIT III

Growth, nutrition requirements, selected media reproduction, preservation of bacterial cultures and variability among phytopathogenic procarya.

UNIT IV

General biology of bacteriophages, L form bacteria, plasmids and bdellovibrios.

UNIT V

Procaryotic inhibitors and their mode of action against phytopathogenic bacteria.

UNIT VI

Survival and dissemination of phytopathogenic bacteria.

Practical

Isolation, purification, identification and host inoculation of phytopathogenic bacteria, staining methods, biochemical and serological characterization, isolation of plasmid and use of antibacterial chemicals/antibiotics. Methods in pure culture studies, microscopy i.e. phase contrast and other microscopes.

Suggested Readings

- Goto M. 1990. Fundamentals of Plant Bacteriology. Academic Press, New York.
- Jayaraman J & Verma JP. 2002. Fundamentals of Plant Bacteriology. Kalyani Publ., Ludhiana.
- Janse JD, 2009. Phytobacteriology: Principles and Practice
- Mount MS & Lacy GH. 1982. Phytopathogenic Prokaryotes. Vols. I, II. Academic Press, New York.
- Verma JP, Varma A & Kumar D. (Eds). 1995. Detection of Plant Pathogens and their Management. Angkor Publ., New Delhi.
- Verma JP. 1998. The Bacteria. Malhotra Publ. House, New Delhi.
- Tripathi,DP. 2008. Introductory Plant Bacteriology, Kalyani Publishers, New Delhi.
- Snyder, L.and Chapness,W.2003. Molecular genetics of Bacteria, ASM Press, American society for Micribiology.

PL PATH 504 : PRINCIPLES OF PLANT PATHOLOGY 3+0

Objective

To introduce the subject of Plant Pathology, its concepts and principles.

Theory

UNIT I

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

UNIT II

Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

UNIT III

Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

UNIT IV

Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

UNIT V

Disease management strategies.

Suggested Readings

- Agrios GN. 2005. Plant Pathology. 5th Ed. Academic Press, New York.
- Heitefuss R & Williams PH. 1976. Physiological Plant Pathology. Springer Verlag, Berlin, New York.
- Mehrotra RS & Aggarwal A. 2003. Plant Pathology. 2nd Ed. Oxford & IBH,, New Delhi.
- Singh RS. 2002. Introduction to Principles of Plant Pathology. Oxford & IBH,, New Delhi.
- Singh DP & Singh A. 2007. Disease and Insect Resistance in Plants. Oxford & IBH,, New Delhi.
- Upadhyay RK & Mukherjee KG. 1997. Toxins in Plant Disease Development and Evolving Biotechnology. Oxford & IBH, New Delhi.

PL PATH 505 : DETECTION AND DIAGNOSIS OF PLANT DISEASES 0+2

Objective

To impart training on various methods/techniques/instruments used in the study of plant diseases/pathogens.

Practical

UNIT I

Methods to prove Koch's postulates with biotroph and necrotroph pathogens, pure culture techniques, use of selective media to isolate pathogens.

UNIT II

Preservation of plant pathogens and disease specimens, use of haemocytometer, micrometer, centrifuge, pH meter, camera lucida.

UNIT III

Microscopic techniques and staining methods, phase contrast system, chromatography, use of electron microscope, spectrophotometer, ultracentrifuge and electrophoretic apparatus, disease diagnostics, serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides, bactericides etc.; field experiments, data collection and preparation of references.

Suggested Readings

- Aneja, KR. 2003. Experiments in Microbiology, Plant Pathology and Biotechnology 4th edition, New Age International Ltd. New Delhi.
- Baudoin ABAM, Hooper GR, Mathre DE & Carroll RB. 1990. Laboratory Exercises in Plant Pathology: An Instructional Kit. Scientific PubL, Jodhpur.
- Chakravarti BP. 2005. Methods of Bacterial Plant Pathology. Agrotech, Udaipur.
- Dhingra OD & Sinclair JB. 1986. Basic Plant Pathology Methods. CRC Press, London, Tokyo
- Forster D & Taylor SC. 1998. Plant Virology Protocols: From Virus Isolation to Transgenic Resistance. Methods in Molecular Biology. Humana Press, Totowa, New Jersey.
- Fox RTV. 1993. Principles of Diagnostic Techniques in Plant Pathology. CABI Wallington.

- Mathews REF. 1993. Diagnosis of Plant Virus Diseases. CRC Press, Boca Raton, Tokyo.
- Matthews REF. 1993. Diagnosis of Plant Virus Diseases. CRC Press, Florida.
- Pathak VN. 1984. Laboratory Manual of Plant Pathology. Oxford & IBH, New Delhi.
- Narayanasamy ,P. 2001. Plant Pathogen Detection and Disease Diagnosis, Marcel Dekker
- Noordam D. 1973. Identification of Plant Viruses, Methods and Experiments. Cent. Agic. Pub. Doc. Wageningen.
- Schots,A,Dewey, FMand Oliver, R.(ed.). 1994. Mordern assey for Plant Pathogenic fungi: Identification,Detection and Qyantification. AB International, Wallingford, Oxford, UK.
- Trigiano RN, Windham MT & Windham AS. 2004. Plant PathologyConcepts and Laboratory Exercises. CRC Press, Florida.

PL PATH 506 : PRINCIPLES OF PLANT DISEASE MANAGEMENT 2+1

Objectives

To acquaint with different strategies for management of plant diseases.

Theory

UNIT I

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases. Disease resistance, **Plant quarantine** and molecular approach for disease management.

UNIT II

Foliage, seed and soil application of chemicals, role of stickers, spreaders and other adjuvants, health vis-a-vis environmental hazards, residual effects and safety measures.

UNIT III

History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals.

Practical

In vitro and *in vivo* evaluation of chemicals against plant pathogens; ED and MIC values, study of structural details of sprayers and dusters.

Suggested Readings

- Fry WE. 1982. Principles of Plant Disease Management. Academic Press, New York.
- HewittHG. 1998. Fungicides in Crop Protection. CABI, Wallington.
- Opender, KG. and Dhaliwal, S. 2000. Phytochemical Biopesticides, CRC Press.
- Marsh RW. 1972. Systemic Fungicides. Longman, New York.
- Nene YL & Thapliyal PN. 1993. Fungicides in Plant Disease Control. Oxford & IBH, New Delhi.
- Palti J. 1981. Cultural Practices and Infectious Crop Diseases. SpringerVerlag, New York.
- Vyas SC. 1993 Handbook of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

PL PATH 507 : DISEASES OF FIELD AND MEDICINAL CROPS 2+1

Objective

To educate about the History, economic importance, disease cycle, nature, prevalence, etiology, factors affecting disease development and control measures of field and medicinal crop diseases.

Theory

UNIT I

Diseases of Cereal crops- wheat, barley, rice, pearl millet, finger millet, sorghum and maize.

UNIT II

Diseases of Pulse crops- gram, urdbean, mungbean, lentil, pigeonpea, soybean, rajmah and cowpea.

UNIT III

Diseases of Oilseed crops- rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor, safflower and niger.

UNIT IV

Diseases of Cash crops- cotton, sugarcane, **tobacco.**

UNIV V

Diseases of Fodder legume crops- berseem, oats, guar, lucerne,

UNIT VI

Medicinal crops- plantago, liquorice, mulathi, rosagrass, senna, guggal, mentha, ashwagandha, Aloe vera.

Practical

Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops. Collection and dry preservation of diseased specimens of important crops.

Suggested Readings

- Joshi LM, Singh DV & Srivastava KD. 1984. Problems and Progress of Wheat Pathology in South Asia. Malhotra Pub I. House, New Delhi.
- Dickson, JG. 2008. Diseases Of Field Crops, Daya Publishing House
- Rangaswami G. 1999. Diseases of Crop Plants in India. 4th Ed.. Prentice Hall ofIndia, New Delhi.
- Ricanel C, Egan BT, Gillaspie Jr AG & Hughes CG. 1989. Diseases of Sugarcane, Major Diseases. Academic Press, New York.
- Singh RS. 1998. Plant Diseases. 7th Ed. Oxford & IBH, New Delhi.
- Singh US, Mukhopadhyay AN, Kumar J & Chaube HS. 1992. Plant Diseases of Internatiobnal Importance. Vol. I. Diseases of Cereals and Pulses. Prentice Hall, Englewood Cliffs, New Jersey.
- Thind, TS. 2005. Diseases Of Field Crops And Their Management , Daya Publishing House

PL PATH 508 : DISEASES OF FRUITS, PLANTATION AND ORNAMENTAL CROPS 2+1

Objective

To educate about the, History, economic importance, disease cycle, nature, prevalence and control measures of diseases of fruits, plantation, ornamental plants and their management.

Theory

UNIT I

Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, **Aonla, custard apple, sapota,** almond, strawberry, citrus, mango, grapes, guava, *ber,* banana, pineapple, papaya, fig, pomegranate, date palm and management of the fruits diseases.

UNIT II

Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber, arecanut, elephant foot(suran) and colocassia, beetle vine and coconut and their management.

UNIT III

Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, orchids, marigold, chrysanthemum, tuberose and gerbera and their management.

Practical

Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops. Collection and dry preservation of diseased specimens of important crops.

Suggested Readings

- Gupta VK &.Sharma SK. 2000. Diseases of Fruit Crops. Kalyani Publ., New Delhi.
- Pathak VN. 1980. Diseases of Fruit Crops. Oxford & IBH, New Delhi.
- Mukerji, KG 2004. Fruit and vegetable diseases, Springer
- Naqvi S. 2004. Diseases of Fruits and Vegetables - Diagnosis and Management, Springer
- Singh RS. 2000. Diseases of Fruit Crops. Oxford & IBH, New Delhi.
- Steferud, A Ed, 2008. Diseases Of Plantation Crops, Daya Publishing House
- Raychaudhuri ,SP 1993. Recent Advances In Medicinal Aromatic And Spice Crops Vol I & II. Today & Tomorrows Print.

- Verma, LR, 1999, Diseases Of Horticultural Crops: Fruits, Indus Publishing Company.
- Ramon, A., Gullino, ML1999, Joop C. Van Lenteren Integrated Pest And Disease Management: In Greenhouse Crops, Springer Netherlands
- Walker JC. 2004. Diseases of Vegetable Crops. TTPP, India.

PL PATH 509 : DISEASES OF VEGETABLE AND SPICES CROPS 2+1

Objective

To educate about the History, economic importance, disease cycle, nature, prevalence and control measures of diseases of vegetables and spices and their management.

Theory

UNIT I

Nature, prevalence, factors affecting disease development of bulb: Onion and garlic, Leafy vegetable: Spinach, Crucifers: Cabbage, cauliflower, radish, Cucurbits and solanaceaous vegetables: Potato, tomato, chilli, brinjal, Diseases of protected cultivation: Okra, pea and carrot.

UNIT II

Symptoms and management of diseases of different root, bulb, leafy vegetables, crucifers, cucurbits and solanaceaous vegetable crops.

UNIT III

Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, cumin, coriander, turmeric, fennel, fenugreek and ginger.

Practical

Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

Suggested Readings

- Chaube HS, Singh US, Mukhopadhyay AN & Kumar J. 1992. Plant Diseases of International Importance. Vol. II. Diseases of Vegetable and Oilseed Crops. Prentice Hall, Englewood Cliffs, New Jersey.
- Gupta VK & Paul YS. 2001. Diseases of Vegetable Crops. Kalyani Publ., New Delhi
- Kumari S. P. 2004. Advances In The Diseases Of Plantation Crops & Spices, International Book Distributing Co
- Sherf AF & Mcnab AA. 1986. Vegetable Diseases and their Control. Wiley InterScience, Columbia.
- Singh RS. 1999. Diseases of Vegetable Crops. Oxford & IBH, New Delhi.
- Gupta SK & Thind TS. 2006. Disease Problem in Vegetable Production. Scientific Publ., Jodhpur.
- Walker JC. 1952. Diseases of Vegetable Crops. McGraw-Hill, New York.

PL PATH 510 : SEED HEALTH TECHNOLOGY 2+1

Objective

To acquaint with seed-borne diseases, their nature, detection, transmission, epidemiology, impacts/loses and management.

Theory

UNIT I

History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

UNIT II

Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

UNIT III

Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of

seed-borne diseases, forecasting of epidemics through seed-borne infection.

UNIT IV

Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogen/diseases and procedure for healthy seed production, seed health testing, methods for detecting microorganism.

Practical

Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses. Management: effect of pH, water treatment , seed soaking, heating technique, washing, chemical seed treatment and certification standard. Relationship between seed-borne infection and expression of the disease in the field.

Suggested Readings

- Agarwal VK & JB Sinclair. 1993. Principles of Seed Pathology. Vols. I & II, CBS PubL, New Delhi.
- Agarwal VK.,2006. Seed Health., International Book Distributing Co., Luknow.
- Mathur,SB and Kongsdal,O., 2001. Common Laboratory Seed Health Testing Methods for Detecting Fungi, Zurich, Switzerland, International Seed Testing Association.
- Hutchins JD & Reeves JE. (Eds.). 1997. Seed Health Testing: Progress Towards the 2Ft Century. CABI, Wallington.
- Paul Neergaard. 1988. Seed Pathology. MacMillan, London.
- Suryanarayana D. 1978. Seed Pathology. Vikash PubL, New Delhi.

PL PATH 511 : CHEMICALS IN PLANT DISEASE MANAGEMENT 2+1

Objective

To impart knowledge on the concepts, principles and judicious use of chemicals in plant disease management.

Theory

UNIT I

History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals.

UNIT II

Classification of chemicals used in plant disease control and their characteristics.

UNIT III

Chemicals in plant disease control, viz., fungicides, bactericides, nematicides, antiviral chemicals and botanicals.

UNIT IV

Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

UNIT V

Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides.

UNIT VI

General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

Practical

Acquaintance with formulation of different fungicides and plant protection appliances. Formulation of fungicides, bactericides and nematicides; *in vitro* evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides based on active ingredients against pathogens; persistence, compatibility with other agro-chemicals; detection of naturally occurring fungicide resistant mutants of pathogen; methods of application of chemicals.

Suggested Readings

- Bindra OS & Singh H. 1977. Pesticides - An Application Equipment. Oxford & IBH, New Delhi.
- Nene YL & Thap1iya1 PN. 1993. Fungicides in Plant Disease Control. 3rd Ed. Oxford & IBH, New Delhi.

❖ Torgeson DC (Ed.). 1969. Fungicides. Vol. II. An Advanced Treatise. Academic Press, New York.
❖ Vyas SC. 1993. Handbook of Systemic Fungicides. Vo1s. I-III. Tata McGraw Hill, New Delhi.

PL PATH 512 : ECOLOGY OF SOIL-BORNE PLANT PATHOGENS 1+1

Objective

To provide knowledge on soil-plant disease relationship.

Theory

UNIT I

Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Types of biocontrol agents.

UNIT II

Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis.

UNIT III

Suppressive soils, biological control- concepts and potentialities for managing soil borne pathogens.

Practical

Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens; pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils; suppression of test soil-borne pathogens by antagonistic microorganisms. Isolation and identification of different biocontrol agents.

Suggested Readings

❖ Baker KF & Snyder WC. 1965. Ecology of Soil-borne Plant Pathogens. John Wiley, New York.
❖ Cook RJ & Baker KF. 1983. The Nature and Practice of Biological Control of Plant Pathogens. APS, St Paul, Minnesota.
❖ Garret SD. 1970. Pathogenic Root-infecting Fungi. Cambridge Univ. Press, Cambridge, New York.
❖ Hillocks RJ & Waller JM. 1997. Soil-borne Diseases of Tropical Crops. CABI, Wallington.
❖ Parker CA, Rovira AD, Moore KJ & Wong PTN. (Eds). 1983. Ecology and Management of Soil-borne Plant Pathogens. APS, St. Paul, Minnesota.

PL PATH 513 : DISEASE RESISTANCE IN PLANTS 2+0

Objective

To acquaint with disease resistance mechanisms in plants.

Theory

UNIT I

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminology.

UNIT II

Disease escapes, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

UNIT III

Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms.

UNIT IV

Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

Suggested Readings

- Deverall BJ. 1977. Defence Mechanisms in Plants. Cambridge Dniv. Press, Cambridge, New York.
- Mills Dallice et a1.1996. Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction. APS, St Paul, Minnesota.
- Parker J. 2008. Molecular Aspects of Plant Diseases Resistance. Blackwell Publ.
- Robinson RA. 1976. Plant Pathosystems. Springer Verlag, New York.
- Singh BD. 2005. Plant Breeding - Principles and Methods. 7th Ed. Kalyani Publ., Ludhiana
- Van der Plank JE. 1975. Principles of Plant Infection. Academic Press, New York.
- Van der Plank JE. 1978. Genetic and Molecular Basis of Plant Pathogenesis. Springer Verlag. New York.
- Van der Plank JE. 1982. Host Pathogen Interactions in Plant Disease. Academic Press, New York.
- Van der Plank JE. 1984. Disease Resistance in Plants. Academic Press, New York.
- Vidhyasekaran, P. and Binghampton, NY. 2003. Bacterial Disease Resistance in Plants. Molecular Biology and Biotechnological Applications.,Haworth Press USA.

PL PATH 514/ ENT 514 : INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS 1+1

Objective

To teach the students about the different groups of insects that vector plant pathogens, vector-plant pathogen interaction, management of vectors for controlling diseases.

Theory

UNIT I

History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.

UNIT II

Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.

UNIT III

Transmission of plant viruses by aphids, whiteflies, mealy bugs thrips, **Nematodes and fungi.**

UNIT IV

Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.

UNIT V

Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

Practical

Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies.

Suggested Readings

- Basu AN. 1995. Bemisia tabaci (Gennadius) - Crop Pest and Principal Whitefly Vector of Plant Viruses. Oxford & IBH, New Delhi.
- Harris KF & Maramarosh K. (Eds.).1980. Vectors of Plant Pathogens. Academic Press, London.
- Maramorosch K & Harris KF. (Eds.). 1979. Leafhopper Vectors and Plant Disease Agents. Academic Press, London.
- Youdeovei A & Service MW. 1983. Pest and Vector Management in the Tropics. English Language Books Series, Longman, London.

PL PATH 515 : BIOLOGICAL CONTROL OF PLANT DISEASES 2+1

Objective

To study principles and application of ecofriendly and sustainable management strategies of plant diseases.

Theory

UNIT I

Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control.

UNIT II

Types of biological interactions, competition, mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control.

UNIT III

Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, biocontrol agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of different bioagents.

UNIT IV

Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents.

Practical

Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen *in vitro and in vivo* conditions. Study of cfu/g, Commercial production of antagonists.

Suggested Readings

- Campbell R. 1989. Biological Control of Microbial Plant Pathogens. Cambridge Univ. Press, Cambridge.
- Cook RJ & Baker KF. 1983. Nature and Practice of Biological Control of Plant Pathogens. APS, St. Paul, Mennisota.
- Fokkemma MJ. 1986. Microbiology of the Phyllosphere. Cambridge Univ. Press, Cambridge. Gnanamanickam SS (Eds). 2002. Biological Control of Crop Diseases. CRC Press, Florida.
- Heikki MT & Hokkanen James M (Eds.). 1996. Biological Control Benefits and Risks. Cambridge Univ. Press, Cambridge.
- Mukerji KG, Tewari JP, Arora DK & Saxena G. 1992. Recent Developments in Biocontrol of Plant Diseases. Aditya Books, New Delhi.

PL PATH 516 : INTEGRATED DISEASE MANAGEMENT 1+1

Objective

To emphasize the importance and need of IDM in the management of diseases of important crops.

Theory

UNIT I

Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications.

UNIT II

Development of IDM- basic principles, biological, chemical and cultural disease management.

UNIT III

IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseedmustard, pearlmillet, *kharif* pulses, vegetable crops and fruit crops.

Practical

Application of biological, cultural, chemical and biocontrol agents, their compatibility and integration in IDM; demonstration of IDM in certain crops as project work.

Suggested Readings

- Gupta VK & Sharma RC. (Eds). 1995. Integrated Disease Management and Plant Health. Scientific Publ., Jodhpur.

❖ Mayee CD, Manoharachary C, Tilak KVBR, Mukadam DS & Deshpande Jayashree (Eds.). 2004. Biotechnological Approaches for the Integrated Management of Crop Diseases. Daya Publ. House, New Delhi.
❖ Opender, KG. and Dhaliwal, S. 2000. Phytochemical Biopesticides, CRC Press.
❖ Sharma RC & Sharma IN. (Eds). 1995. Integrated Plant Disease Management. Scientific Publ., Jodhpur.

PL PATH 517 : MUSHROOM PRODUCTION TECHNOLOGY 2+1

Objective

To develop mushroom cultivation skills for entrepreneurial activity. Historical development of mushroom cultivation and present status of mushroom industry in India.

Theory

UNIT I

Historical development of mushroom cultivation and present status, taxonomy, classification, food, medicinal value, uses of mushroom, edible and poisonous mushrooms.

UNIT II

Life cycle of cultivated mushrooms, reproduction and strain improvement, maintenance of pure culture, preparation of spawn and facilities required for establishing commercial spawn lab.

UNIT III

Preparation of substrate for mushroom cultivation, long, short and indoor compo sting methods, formulae for different composts and their computation, qualities and testing of compost, uses of spent mushroom compost/substrate.

UNIT IV

Facilities for setting up mushroom farm for seasonal and environmentally control cultivation, requirement and maintenance of temperature, relative humidity, C02, ventilation in cropping rooms, cultivation technology of *Agaricus bisporus, Pleurotus* sp., *Calocybe indica, Lentinus edodes* and *Ganoderma lucidum.*

UNIT V

Insect pests, diseases and abnormalities of cultivated mushroom and their management, post harvest processing and value addition, economics of mushroom cultivation, biotechnology and mushroom cultivation.

Practical

Preparation of spawn, compost, spawning, casing, harvesting and postharvest handling of edible mushroom; identification of various pathogens, competitors of various mushroom.

Suggested Readings

❖ Chadha KL & Sharma SR. 2001. Advances in Horticulture (Mushroom). Vol. XIII. Malhotra Publ. House, New Delhi.
❖ Chang ST & Hays W A. 1997. The Biology and Cultivation of Edible Mushrooms. Academic Press, New York.
❖ Chang ST & Miles PG. 2002. Edible Mushrooms and their Cultivation. CRC Press, Florida.
❖ Kapur IN. 1989. Mushroom Cultivation. DIPA, ICAR, New Delhi.
❖ Dhar BL. 2005. Cultivation Technology of High Temperature Tolerant White Button Mushroom. DIPA, ICAR, New Delhi.

PLPATH 518 : EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES 2+1

Objective

To acquaint with the principles of epidemiology and its application in disease forecasting.

Theory

UNIT I

Epidemic concept and historical development, pathometry and crop growth stages, epidemic growth and analysis.

UNIT II

Common and naturallogrithms, function fitting area under disease progress curve and correction factors, inoculum dynamics, population biology of pathogens, temporal spatial variability in plant pathogens.

UNIT III

Survey, surveillance and vigilance, crop loss assessment and models.

UNIT IV

Principles and pre-requisites of forecasting, systems and factors affecting various components of forecastings, some early forecasting, procedures based on weather and inoculum potential, modeling disease growth and disease prediction.

Practical

Measuring diseases, spore dispersal and trapping, weather recording, survey, multiplication of inoculum, computerized data analysis, function fitting, model preparation and validation.

Suggested Readings

- Campbell CL & Madden LV. 1990. Introduction to Plant Disease Epidemiology. John Wiley & Sons. New York
- Cowling EB & Horsefall JG. 1978. Plant Disease. Vol. II. Academic Press, New York.
- Laurence VM, Gareth H & Frame Van den Bosch (Eds.). The Study of Plant Disease Epidemics. APS, St. Paul, Minnesota.
- Nagarajan S & Murlidharan K. 1995. Dynamics of Plant Diseases. Allied PubL, New Delhi.
- Thresh JM. 2006. Plant Virus Epidemiology. Advances in Virus Research 67, Academic Press, New York.
- Van der Plank JE. 1963. Plant Diseases Epidemics and Control. Academic Press, New York.
- Zadoks JC & Schein RD. 1979. Epidemiology and Plant Disease Management. Oxford Univ. Press, London.

PL PATH 519 : POST HARVEST DISEASES 2+1

Objective

To acquaint with post harvest diseases of agricultural produce and their ecofriendly management.

Theory

UNIT I

Concept of post harvest diseases, definitions, importance with reference to environment and health, principles of plant disease management as preharvest and post-harvest, merits and demerits ofbiologicallphytoextracts in controlling post-harvest diseases.

UNIT II

Types of post harvest problems both by biotic and abiotic causes, rhizosphere colonization, competitive, saprophytic ability, antibiosis, induced resistance, microbial associations, concept, operational mechanisms and its relevance in control.

UNIT III

Factors governing post harvest problems both as biotic and abiotic, role of physical environment, agro-ecocystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents, oils, botanical pesticides, chemicals, physical methods and resistant varieties in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists. Isolation, characterization and maintenance of pathogens, role of different storage.

UNIT IV

Integrated approach in controlling diseases and improving the shelf life of produce, control of atlatoxigenic and mycotoxigenic fungi, application and monitoring for any health hazard, knowledge of Codex Alimentarious for each product and commodity.

Practical

Isolation characterization and maintenance of pathogens, role of different storage conditions on disease development, application of antagonists against pathogens *in vivo* and *in vitro* conditions. Comparative efficacy of different chemicals, fungicides, phytoextracts and bioagents.

Suggested Readings

- Pathak VN. 1970. Diseases of Fruit Crops and their Control. IBH Publ., New Delhi.
- Chaddha KL & Pareek OP. 1992. Advances in Horticulture Vol. IV, Malhotra Publ. House, New Delhi.

PL PATH 520/ ENT 520 : PLANT QUARANTINE 2+0

Objective

To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up.

Theory

UNIT I

Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine - domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

UNIT II

Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export ofbio-control agents.

UNIT III

Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestation/salvaging of infected material.

UNIT IV

WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Suggested Readings

- Rajeev K & Mukherjee RC. 1996. Role of Plant Quarantine in IPM. Aditya Books.
- Rhower GG. 1991. Regulatory Plant Pest Management. In: Handbook of Pest Management in Agriculture. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.
- Ebbels, DL and. Ebbel, DS. 2003. Principles Of Plant Health And Quarantine. CABI Publishing

PL PATH 601 : ADVANCED MYCOLOGY 2+1

Objective

To acquaint with the latest advances in Mycology.

Theory

UNIT I

General introduction, historical development and advances in mycology.

UNIT II

Recent taxonomic criteria, morphological criteria for classification. Serological, Chemical (chemotaxonomy), Molecular and Numerical (Computer based assessment) taxonomy.

UNIT III

Interaction between groups: Phylogeny. Micro conidiation, conidiogenesis and sporulating structures of fungi imperfecti. Morphology and reproduction of representative plant pathogenic genera from different groups of fungi. Sexual reproduction in different groups of fungi.

UNIT IV

Population biology, pathogenic variability/vegetative compatibility.

UNIT V

Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra-nuclear inheritance. Biodegradation.

Practical

Study of conidiogenesis- phialides, porospores, arthospores. Study of fruit bodies in Ascomycotina. Identification of fungi up to species level. Study of hyphal anastomosis. Morphology of representative plant pathogenic genera from different groups of fungi.

Suggested Readings

- Alexopoulos CJ, Mimms CW & Blackwell M. 1996. Introductory Mycology. John Wiley & Sons, New York.
- Dube HC. 2005. An Introduction to Fungi. 3rd Ed. Vikas Publ. House, New Delhi.
- Kirk PM, Cannon PF, David JC & Stalpers JA. (Eds.). 2001. Ainswsorth and Bisby's Dictionary of Fungi. 9th Ed., CABI, Wallington.
- Ulloa M & Hanlin RT. 2000. Illustrated Dictionary of Mycology. APS, St. Paul, Mennisota.
- Webster J & Weber R. 2007. *Introduction to Fungi.* Cambridge Univ. Press, Cambridge.

PL PATH 602 : ADVANCED VIROLOGY 2+1

Objective

To educate about the advanced techniques and new developments in the field of Plant Virology.

Theory

UNIT I

Origin, evolution and interrelationship with animal viruses. Mechanism of virus transmission by vectors, virus-vector relationship, bimodal transmission and taxonomy of vectors and viruses, vector specificity for classes of viruses, virus replication, assembly and architecture, ultrastructural changes due to virus infection, variation, mutation and virus strains.

UNIT II

Immunoglobulin structure and functions of various domains, methods of immunodiagnosis, hybridoma technology and use of monoclonal antibodies in identification of viruses and their strains, Polymerase Chain Reaction.

UNIT III

Genome organization, replication, transcription and translational strategies of pararetroviruses and gemini viruses, satellite viruses and satellite RNA genome organization in tobamo-, poty-, bromo, cucummo, ilar and tospoviruses.

UNIT IV

Gene expression and regulation, viral promoters, molecular mechanism of host virus interactions, virus induced gene, molecular mechanism of vector transmission, symptom expression, viroids and prions.

UNIT V

Genetic engineering with plant viruses, viral suppressors, a RNAi dynamics, resistant genes. Viruses potential as vectors, genetically engineered resistance, transgenic plants.

UNIT VI

Techniques and application of tissue culture. Origin, evolution and interrelationship with animal viruses.

Practical

Purification of virus(es), SDS-PAGE for molecular weight determination, production of polyclonal antiserum, purification of IgG and conjugate preparation, serological techniques (i) DAC-ELISA (ii) DAS -ELISA (iii) DffiA (iv) Western blots (v) (ab) 2-ELISA, vector transmission (one each with aphid, leaf hopper and whitefly), methods for collecting vectors and their maintenance, nucleic acid isolation, DOT -blot, southern hybridization, probe preparation and autoradiography, PCR application and viral genome cloning, sequencing annotation of genes.

Suggested Readings

- Davies 1997. Molecular Plant Virology: Replication and Gene Expression. CRC Press, Florida.
- Fauquet et al. 2005. Virus Taxonomy. VIII Report of ICTV. Academic Press, New York.
- Gibbs A & Harrison B. 1976. Plant Virology - The Principles. Edward Arnold, London.
- Jones P, Jones PG & Sutton JM. 1997. Plant Molecular Biology: Essential Techniques. John Wiley & Sons, New York.
- Khan JA & Dijkstra. 2002. Plant Viruses as Molecular Pathogens. Howarth Press, New York.
- Maramorosch K, Murphy FA & Shatkin AJ. 1996. Advances in Virus Research. Vol. 46. Academic Press, New York.

- Pirone TP & Shaw JG. 1990. Viral Genes and Plant Pathogenesis. Springer Verlag, New York.
- Roger Hull 2002. Mathew's Plant Virology (4th Ed.). Academic Press, New York.
- Thresh JM. 2006. Plant Virus Epidemiology. Advances in Virus Research 67. Academic Press, New York.

PL PATH 603 : ADVANCED BACTERIOLOGY 2+1

Objective

To provide knowledge about the latest advances in phytobacteriology.

Theory

UNIT I

Current approaches for the characterization and identification of phytopathogenic bacteria. Ultrastructures and biology of bacteria.

UNIT II

Current trends in taxonomy of phytopathogenic procarya.: Chemotaxonomy**,** fatty acid and protein profile, characterization and approaches for identification of bacteria including nucleic acid technology, genomic finger printing and computer based identification of bacteria. Plasmid biology i.e. Plasmid profile and RFLP,

UNIT III

Role of enzyme, toxin, expolysaccharide, polypeptide signals in disease development. Mechanism of wilt *(Ralstonia solanacearum)* development, mechanism of soft rot *(Erwinia* spp.) development, mechanism of Crown gall formation *(Agrobacterium tumifaciens).*

UNIT IV

Host-bacterial pathogen interaction, quorum-sensing phenomenon, Type III secretion system, HR/SR reactions, R-genes, Avr-genes, hrp genes, Effector protein.

UNIT V

Molecular variability among phytopathogenic procarya and possible host defense mechanism(s). Genetic engineering for management of bacterial plant pasthogens-gene silencing, RNAi technology.

UNIT VI

Epidemiology in relation to bacterial plant pathogens. Development of diagnostic kit.

UNIT VII

Beneficial prokaryotes- Endophytes, PGPR, phylloplane bacteria and their role in disease management. Endosymbionts for host defence.

Practical

Pathogenic studies and race identification; plasmid profiling of bacteria; fatty acid profiling of bacteria; RAPD prolfi1ing of bacteria and variability status; Endospore, Flagiler staining; test for secondary metabolite production, cyanides, EPS, siderophore; specific detection of phytopathogenic bacteria using species/pathovar specific primers. Basic techniques in diagnostic kit development, molecular tools to identify phytoendosymbionts.

Suggested Readings

- Dale JW & Simon P. 2004. Molecular Genetics of Bacteria. John Wiley & Sons, New York.
- Garrity GM, Krieg NR & Brenner DJ. 2006. Bergey's Manual of Systematic Bacteriology: The Proteobacteria. Vol. II. Springer Verlag, New York.
- Gnanamanickam SS. 2006. Plant-Associated Bacteria. Springer Verlag, New York.
- Mount MS & Lacy GH. 1982. Plant Pathogenic Prokaryotes. Vols. I, II. Academic Press, New York.
- Sigee DC. 1993. Bacterial Plant Pathology: Cell and Molecular Aspects. Cambridge Dniv. Press, Cambridge.
- Starr MP. 1992. The Prokaryotes. Vols. I - IV. Springer Verlag, New York.
- Snyder, L.and Chapness,W.2003. Molecular genetics of Bacteria, ASM Press, American society for Micribiology

PL PATH 604 : MOLECULAR BASIS OF HOST-PATHOGEN INTERACTION 2+1

Objective

To understand the concepts of molecular biology and biotechnology in relation to host-pathogen interactions.

Theory

UNIT I

Importance and role of biotechnological tools in Plant Pathology- Basic concepts and principles to study host pathogen relationship.

UNIT II

Molecular basis of host-pathogen interaction- fungi, bacteria and viruses; recognition system, signal transduction.

UNIT III

Induction of defense responses- pathogenesis related proteins, HR, reactive oxygen species, phytoalexins and systemic acquired resistance, Programmed Cell Death, Viral induced gene silencing.

UNIT IV

Molecular basis of gene-for-gene hypothesis; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding ofR genes.

UNIT V

Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, biosafety issues related to GM crops.

Practical

Protein, DNA and RNA isolation, Plasmids extraction, PCR analysis, DNA and Protein electrophoresis, bacterial transformation.

Suggested Readings

- Chet I. 1993. Biotechnology in Plant Disease Control. John Wiley & Sons, New York.
- Gurr SJ, Mc Pohersen MJ & Bowlos DJ. (Eds.). 1992. Molecular Plant Pathology - A Practical Approach. Vols. I & II, Oxford Dniv. Press, Oxford.
- Mathew JD. 2003. Molecular Plant Pathology. Bios Scientific PubL, UK.
- Ronald PC. 2007. Plant-Pathogen Interactions: Methods in Molecular Biology. Humana Press, New Jersey.
- Sambrook, J. and Rurseell,DW. 2001. Molecular Cloning- A laboratory manual, Vol. I,II &III. Cold spring harbor laboratory. Press, New York.
- Stacey G & Keen TN. (Eds.). 1996.Plant Microbe Interactions. Vols.I-III. Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.
- Snyder, L.and Chapness,W. 2003. Molecular genetics of Bacteria, ASM Press, American society for Micribiology

PL PATH 605 : PRINCIPLES AND PROCEDURES OF CERTIFICATION 1+0

Objective

To acquaint with certification procedures of seed and planting material.

Theory

UNIT I

Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD etc. in certification and quality control.

UNIT II

Case studies of certification systems of USA and Europe. National Regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing genetic identity, physical purity, germination percentage, seed health etc.

UNIT III

Fixing tolerance limits for diseases and insect pests in certification and quality control programmes. Methods used in certification of seeds, vegetative propagules and *in vitro*

cultures. Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.

Suggested Readings

- Association of Official Seed Certifying Agencies.http://www.aosca.org/index.htm.
- Hutchins D & Reeves JE. (Eds.). 1997. Seed Health Testing: Progress Towards the 2Ft Century. CABI, UK.
- ISHI-veg Manual of Seed Health Testing Methods. http://www.worldseed.org/en us/international_ seed/ishi _vegetable.html
- ISHI-F Manual of Seed Health Testing Methods.http://www.worldseed.org/en-us/international_ seed/ism _ f.html
- ISTA Seed Health Testing Methods. http://www.seedtest.org/en/content--1--1132--241.html
- Tunwar NS & Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, Department of Agriculture and Cooperation, Ministry of Agriculture, Government ofIndia, New Delhi.
- US National Seed Health System. http://www.seedhealth.org/

PL PATH 606 : PLANT BIOSECURITY AND BIOSAFETY 2+0

Objective

To facilitate deeper understanding on plant biosecurity and biosafety issues in agriculture.

Theory

UNIT I

History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Biowarfare, Emerging/resurgence of pests and diseases.

UNIT II

National Regulatory Mechanism and International Agreements/Conventions viz., Agreement on Application of Sanitary and Phytosanitary (SPS) Measures/World Trade Organization (WTO), Convention on Biological Diversity (CBD), International Standards for Phytosanitary Measures, pest risk analysis, risk assessment models, pest information system, early warning and forecasting system, use of Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity.

UNIT III

Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops.

Suggested Readings

- F AO Biosecurity Toolkit 2008. www.fao.org/docrep/01O/al140e/al140eOO.htm Laboratory Biosecurity Guidance.
- http://www. who.int/csr/resources/publications/biosafety/WHO CD S EPR 2006.pdf
- Grotto Andrew J & Jonathan B Tucker. 2006. Biosecurity: A Comprehensive Action Plan.
- http://www.americanprogress.org/kf/biosecurity a comprehensive action --'plan.pdf
- Biosecurity Australia. www.daff.gov.au/ba;www.affa.gov.au/biosecurityaustralia Biosecurity New Zealand. www.biosecurity.govt.nz
- DEFRA. www.defra.gov.uk/animalh/diseases/control/biosecurity/index.htm
- Randhawa GJ, Khetarpal RK, Tyagi RK & Dhillon. BS (Eds.). 2001. Transgenic Crops and Biosafety Concerns. NBPGR, New Delhi.
- Khetarpal RK & Kavita Gupta 2006. Plant Biosecurity in India - Status and Strategy. Asian Biotechnology and Development Review 9(2): 3963. Biosecurity for Agriculture and Food Production.
- http://www.fao.org/biosecuritv/ CFIA.http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.sht ml

AGRICULTURAL ECONOMICS

AG ECON 501 : MICRO ECONOMIC THEORY AND APPLICATIONS 2+0

Objective

This course is intended to provide an overview of microeconomic theory and its applications. The course starts with the theory of consumer behaviour consisting of consumer's utility maximization problem and demand theory. It intends to provide fundamental concepts and models in the theory of production and costs and sets out to provide a basic understanding of price and / or output determination under different types of market structures including factor markets. This course will also expose the students to the theory of general equilibrium and welfare economics.

Theory

UNIT I

Theory of Consumer Behaviour - Cardinal Utility Approach - Ordinal Utility Approach - Income effect and substitution effect - Applications of Indifference curve approach - Revealed Preference Hypothesis - Consumer surplus - Derivation of Demand curve - Elasticity of demand.

UNIT II

Theory of Production - Production functions - Returns to scale and economies of scale - - Theory of Costs - Cost curves: Profit maximization and cost minimization - Derivation of supply curve Law of Supply - Producers' surplus.

UNIT III

Market Equilibrium - Behaviour of Firms in Competitive Markets - Perfect Competition- Effect of Taxation and Subsidies on market equilibrium Monopoly- Monopolistic - Oligopoly- Theory of Factor Markets.

UNIT IV

General Equilibrium Theory - Welfare Economics - Pareto Optimality Social welfare criteria - Social Welfare functions.

Suggested Readings

- David M Kreps 1990. A Course in Microeconomic Theory. Princeton University Press.
- Dewitt KK. 2002. Modern Economic Theory. Sultan Chand & Co.
- Henderson JM & Quandt RE. 2000. Microeconomic Theory: A Mathematical Approach. McGraw-Hill.
- Koutsoyiannis A. 2003. Modern Microeconomics. The Macmillan Press.
- Silberberg E & Suen W. 2001. The Structure of Economics - A Mathematical Analysis. McGraw-Hill.
- Varian Hal R. 1999. *Intermediate Microeconomics.* Affiliated East-West Press.

AG ECON 502 : MACRO ECONOMICS AND POLICY 2+0

Objective

Macro economics and Policy course is intended to expose the students to macroeconomic concepts and theory, the application of the macro economic theory, and implication of the macroeconomic policies.

Theory

UNIT I

Nature and Scope of Macro Economics -Classical theory of Employment and Say's Law-Methodology and Keynesian Concepts -National Income - Concepts and measurement-Modern theory of Employment and Effective Demand. - Unemployment and Full employment.

UNIT II

Consumption function- Investment and savings - Concept of Multiplier and Accelerator - Output and Employment - Rate of interest - Classical, Neo classical and Keynesian version-

Classical theory Vs Keynesian theory

UNIT III

Money and classical theories of Money and Price - Keynesian theory of money and Friedman Restatement theory of money - Supply of Money -Demand for Money -Inflation: Nature, Effects and control.

UNIT IV

IS & LM frame work - General Equilibrium of product and money markets -Monetary policy - Fiscal policy- Effectiveness of Monetary and Fiscal policy - Central banking.

UNIT V

Business cycles - Balance of Payment - Foreign Exchange Rate determination.

Suggested Readings

- Ahuja HL. 2007. Macroeconomics: Theory and Policy. S. Chand & Co.
- Eugene A Diulio 2006. Macroeconomics. 4th Ed. Schaums' Outlines.
- Gardner Ackely 1987. Macro Economic: Theory and Policy. Collier Macmillan.
- Dornbusch. 2006. *Macroeconomics.* McGraw Hill Publication

AG ECON 503 : EVOLUTION OF ECONOMIC THOUGHT 1+0

Objective

To introduce the students to the evolution of economic thought over a period of time, the background of emanation of thoughts and approaches, as acts of balancing and counter balancing events and criticisms. The course will also in a comprehensive way help the students to know and appreciate the contributions of the Galaxy of Economists.

Theory

UNIT I

Approaches for the study of history of economic thought - Absolutist vs. Relativist approaches - Evolution of Economic Thought vs. Economic History. Ancient economic thought - medieval economic thought -mercantilism - physiocracy - Forerunners of Classical Political Economy.

UNIT II

Development of Classical Thoughts (Adam Smith, Robert Malthus and David Ricardo) - Critics of Classical Thoughts- Socialist critics - Socialist and Marxian Economic Ideas - Austrian School of Thought - Origins of Formal Microeconomic Analysis - William Stanley Jevons, Cournot and Dupuit.

UNIT III

The birth of neoclassical economic thought - Marshall and Walras General Equilibrium Theory - Welfare Theory - Keynesian economics.

UNIT IV

The Era of globalization - Experiences of developing world - Rigidity of the past vs. emerging realism - The changing path of international Institutions to economic growth and development approaches.

UNIT V

Economic Thought in India - Naoroji and Gokhale - Gandhian Economics - Economic thought of independent India - Nehru's economic philosophy -Experiences of the Structural adjustment programmes of the post liberalization era.

Suggested Readings

- Blaug M. 1964. Economic Theory in Retrospect. Heineman.
- Blaug M. 1986. Economic History and the History of Economic Thought. Wheatsheaf Books, Brighton.
- Ekelund RB & Hebert RF. 1975. A History of Economic Theory and Methods. McGraw-Hill.
- John Mills A. 2002. Critical History of Economics: Missed Opportunities. Pal grave Macmillan.
- Screpanti E & Zamagni S. 1995. An Outline of the History of Economic Thought. Clarendon Press, Oxford.

AG ECON 504 : AGRICULTURAL PRODUCTION ECONOMICS 2+1

Objective

To expose the students to the concept, significance and uses of agricultural production economics.

Theory

UNIT I

Nature, scope and significance of agricultural production economics Agricultural Production processes, assumptions of production functions, commonly used forms - Properties, limitations, specification, estimation and interpretation of commonly used production functions.

UNIT II

Factors of production, classification, interdependence, and factor substitution -Determination of optimal levels of production and factor application -Optimal factor combination and least cost combination of production.

UNIT III

Cost functions and cost curves, components, and cost minimization -uality theory - cost and production functions and its applications. -Derivation of firm's input demand and output supply functions -Economies and diseconomies of scale.

UNIT IV

Technology in agricultural production, nature and effects and measurement - Measuring efficiency in agricultural production; technical, allocative and economic efficiencies - Yield gap analysis-concepts-types and measurement - Nature and sources of risk and uncertainty

Practical

Different forms of production functions - specification, estimation and interpretation of production functions - returns to scale, factor shares, elasticity of production - physical optima-economic optima-least cost combination- optimal product choice- cost function estimation, interpretation-estimation of yield gap - incorporation of technology in production functions-measuring returns to scale-risk analysis.

Suggested Readings

- Beattie BR & Taylor CR. 1985. The Economics of Production. John Wiley & Sons.
- Doll JP & Frank O. 1978. Production Economics - Theory and Applications. John Wiley & Sons.
- Gardner BL & Rausser GC. 2001. Handbook of Agricultural Economics. Vol. 1. Agricultural Production. Elsevier.
- Heady EO. Economics of Agricultural Production and Resource Use. Prentice-Hall.
- Sankayan PL. 1983. Introduction to Farm Management. Tata Mc Graw Hill.
- Heady EO. & Dhilon JL. *Agricultural Production Function.* Kalyani Publishers

AG ECON 505 : AGRICULTURAL MARKEI1NG AND PRICE ANALYSIS 2+1

Objective

To impart adequate knowledge and analytical skills in the field of agricultural marketing issues, and enhance expertise in improving the performance of the marketing institutions and the players in marketing of agricultural commodities.

Theory

UNIT I

Review of Concepts in Agricultural Marketing - Characteristic of Agricultural product and Production - Problems in Agricultural Marketing from Demand and Supply and Institutions sides. Market intermediaries and their role - Need for regulation in the present context - Marketable & Marketed surplus estimation. Marketing Efficiency - Structure Conduct and Performance analysis - Vertical and Horizontal integration - Integration over space, time and form-Vertical co-ordination.

UNIT II

Marketing Co-operatives - APMC Regulated Markets - Direct marketing, Contract farming and Retailing - Supply Chain Management - State trading, Warehousing and other Government agencies -Performance and Strategies - Market infrastructure needs, performance and Government role - Value Chain Finance.

UNIT III

Role of Information Technology and telecommunication in marketing of agricultural commodities - Market research-Market information service electronic auctions (e-bay), e-Chaupals, Agmarket and Domestic and Export market Intelligence Cell (DEMIC) - Market extension.

UNIT IV

Spatial and temporal price relationship - price forecasting - time series analysis - time series models - spectral analysis. Price policy and economic development - non-price instruments.

UNIT V

Theory of storage - Introduction to Commodities markets and future trading - Basics of commodity futures - Operation Mechanism of Commodity markets - Price discovery - Hedging and Basis - Fundamental analysis Technical Analysis - Role of Government in promoting commodity trading and regulatory measures.

Practical

Supply and demand elasticities in relation to problems in agricultural marketing. Price spread and marketing efficiency analysis. Marketing structure analysis through concentration ratios.Performance analysis of Regulated market and marketing societies. Analysis on contract farming and supply chain management of different agricultural commodities, milk and poultry products.

Chain Analysis - quantitative estimation of supply chain efficiency - Market Intelligence - Characters, Accessibility, and Availability Price forecasting. Online searches for market information sources and interpretation of market intelligence reports - commodity outlook - Technical Analysis for important agricultural commodities. Fundamental Analysis for important agricultural commodities Presentation of the survey results and wrap-up discussion.

Suggested Readings

- Purecell WD & Koontz SR. 1999. Agricultural Futures and Options: Principles and Strategies. 2nd Ed. Prentice-Hall.
- Rhodes VI. 1978. The Agricultural Marketing System. Grid Publ., Ohio.
- Shepherd SG & Gene AF. 1982. Marketing Farm Products. Iowa State Univ. Press.
- Singhal AK. 1986. *Agricultural Marketing in India.* Annual Publ., New Delhi.

AG ECON 506 : RESEARCH METHODOLOGY FOR SOCIAL SCIENCES 1+1

Objective

To expose the students to research methodology used in social sciences. The focus will be on providing know ledge related to research process, data collection and data analysis etc.

Theory

UNIT I

Importance and scope of research in agricultural economics. Types of research - Fundamental vs. Applied. Concept of researchable problem, research prioritization - selection of research problem. Approach to research - research process.

UNIT II

Hypothesis - meaning - characteristics - types of hypothesis - review of literature - setting of Course Objective and hypotheses - testing of hypothesis.

UNIT III

Sampling theory and sampling design - sampling error - methods of sampling - probability and non-probability sampling methods- criteria to choose. Project proposals - contents and scope - different types of projects to meet different needs - trade-off between scope and cost of the study. Research design and techniques - Types of research design.

UNIT IV

Data collection - assessment of data needs - sources of data collection discussion of different situations. Mailed questionnaire and interview schedule - structured, unstructured, open ended and closed-ended questions. Scaling Techniques. Preparation of schedule - problems in measurement of variables in agriculture. Interviewing techniques and field problems - methods of conducting survey - Reconnaissance survey and Pre testing.

UNIT V

Coding editing - tabulation - validation of data. Tools of analysis - data processing. Interpretation of results - Preparing research report / thesis Universal procedures for preparation of bibliography - writing of research articles.

Practical

Exercises in problem identification. Project proposals - contents and scope. Formulation of Objective and hypotheses. Assessment of data needs sources of data - methods of collection of data. Methods of sampling criteria to choose - discussion on sampling under different situations. Scaling Techniques - measurement of scales. Preparation of interview schedule - Field testing. Method of conducting survey. Exercise on coding, editing, tabulation and validation of data. Preparing for data entry into computer. Hypothesis testing - Parametric and Non-Parametric Tests. Exercises on format for Thesis / Report writing. Presentation of the results.

Suggested Readings

- ❖ Black TR. 1993. Evaluating Social Science Research - An Introduction. SAGE Publ.
- ❖ Creswell JW. 1999. Research Design - Qualitative and Quantitative Approaches. SAGE Publ.
- ❖ Dhondyal SP. 1997. Research Methodology in Social Sciences and Essentials of Thesis Writing. Amman Publ. House, New Delhi.
- ❖ Kothari CR. 2004. Research Methodology - Methods and Techniques. Wishwa Prakashan, Chennai.
- ❖ Rao KV. 1993. Research Methodology in Commerce and Management. Sterling Publ., New Delhi.
- ❖ Singh AK. 1993. Tests, Measurements and Research Methods in Behavioural Sciences. Tata McGraw-Hill.
- ❖ Venkatasubramanian V. 1999. Introduction to Research Methodology in Agricultural and Biological Sciences. SAGE Publ.

AG ECON 507 : ECONOMETRICS 2+1

Objective

The objective of the course is to impart knowledge on econometric tools to the students of agricultural economics. Training in econometrics will help the student to analyze the economic problem by applying quantitative techniques.

Theory

UNIT I

Introduction - relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics, regression analysis, assumptions of random disturbance term

UNIT II

Properties of BLUE -Basic two variable regression - estimation and interpretation approaches to estimation - OLS, and their properties - extensions to multi variable models-multiple regression estimation and interpretation.

UNIT III

Violation of assumptions - identification, consequences and remedies for multicollinearity, heteroscedasticity, autocorrelation - data problems and remedial approaches - model misspecification.

UNIT IV

Use of dummy variables- specification, estimation and interpretation.

UNIT V

Simultaneous equation models - structural equations - reduced form equations - identification and approaches to estimation.

Practical

Single equation two variable model, specification and estimation, hypothesis testing-transformations of functional forms and OLS application-estimation of multiple regression model - testing and managing Multicollinearity - testing and managing heteroscedasticity - testing and managing autocorrelation – Estimation of regressions with dummy variables -

identification of equations in simultaneous equation systems.

Suggested Readings

- Gujarati DN. 2003. Basic Econometrics. McGraw Hill.
- Johnson AG Jr., Johnson MB & Buse RC. 1990. Econometrics - Basic and Applied. MacMillan.
- Kelejan HH & Oates WE. 1994.Introduction to Econometrics Principles and Applications. Harper and Row Publ.
- Koutsoyianis A. 1997. Theory of Econometrics. Barner & Noble.
- Maddala GS. 1992. Introduction to Econometrics. MacMillan.
- Maddala GS. 1997. Econometrics. McGraw Hill.
- Pindyck RS & Rubinfeld DL. 1990. Econometrics Models and Econometric Forecasts. McGraw Hill.

AG ECON 508 : LINEAR PROGRAMMING 1+1

Objective

The objective of the course is to impart knowledge of Linear programming techniques.

Theory

UNIT I

Decision Making-Concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.

UNIT II

Simplex Method: Concept of simplex Method, solving profit maximization and cost minimizations problems. Formulation of farms and non farm problems as linear programming models and solutions. Sensitivity analysis.

UNIT III

Extension of Linear Programming models: Integer programming -Variable resource and price programming, transportation problems, recursive programming, dynamic programmmg.

UNIT IV

Game Theory- Concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies, the rectangular game as Linear Programme.

Practical

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the simplex matrices for typical farm situations.

Suggested Readings

- Dorfman R. 1996. Linear Programming & Economic Analysis. McGraw Hill.
- Loomba NP.2006. Linear Programming. Tata McGraw Hill.
- Shenoy G. 1989. Linear Programming-Principles & Applications. Wiley Eastern Publ.
- Vaserstein. 2006. *Introduction to Linear Programming.* Pearson Education Publication.

AG ECON 509 : AGRICULTUIRAL FINANCE AND PROJECT MANAGEMENT 2+1

Objective

The Course objective is to impart knowledge on issues related to lending to priority sector credit management and financial risk management. The course would bring in the various appraisal techniques in project - investment of agricultural projects.

Theory

UNIT I

Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending - Direct and Indirect Financing - Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's - NGO's, and SHG's.

UNIT II

Lending to farmers - The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit

proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions - credit widening and credit deepening.

UNIT III

Financial Decisions - Investment, Financing, Liquidity and Solvency. Preparation of financial statements - Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and Assessing the performance of farm/firm.

UNIT IV

Project Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques - Undiscounted measures. Time value of money - Use of discounted measures - B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Net work Techniques - PERT and CPM.

UNIT V

Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes - review of different crop insurance schemes - yield loss and weather based insurance and their applications.

Practical

Development of Rural Institutional Lending - Branch expansion, demand and supply of institutional agricultural credit. Over dues and Loan waiving- : An overview, Rural Lending Programmes of Commercial Banks, Lead Bank Scheme- Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions, Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through financial statements, Performance of Micro Financing Institutions - NGO's and Self-Help Groups, Identification and formulation of investment projects, Project appraisal techniques Undiscounted Measures and their limitations. Project appraisal techniques - Discounted Measures, Network techniques - PERT and CPM for project management, Case Study Analysis of an Agricultural project, Financial Risk and risk management strategies - crop insurance schemes, Financial instruments and methods - E banking, Kisan Cards and core banking.

Suggested Readings

- Dhubashi PRo 1986. Policy and Perfonnance - Agricultural and Rural Development in Post Independent India. Sage Publ.
- Gittinger JP 1982. Economic Analysis of Agricultural Projects. The Johns Hopkins Univ. Press.
- Gupta SC. 1987. Development Banking for Rural Development. Deep & Deep Publ.
- Little IMD & Mirlees JA. 1974. Project Appraisal and Planning for Developing Countries. Oxford & IBH Publ.
- Muniraj R. 1987. *Fann Finance for Development.* Oxford & IBH Publ.

AG ECON 510 : INTERNATIONAL ECONOMICS 1+1

Objective

The expected outcome of this course will be creating awareness among the students about the role of International Economics on National welfare.

Theory

UNIT I

Scope and Significance of International Economics - The role of trade. General Equilibrium in a Closed Economy (Autarky Equilibrium) Equilibrium in a Simple Open Economy - Possibility of World Trade gains and Trade Equilibrium.

UNIT II

Tariff, Producer Subsidy, Export Subsidy, Import Quota and Export Voluntary Restraints- The Case of Small Country and Large Country Case.

UNIT III

Ricardian Model of Trade- Specific Factors Model- Heckscher - Ohlin Model - Trade Creation and Trade Diversion - Offer Curve - Export Supply Elasticity and Import Demand Elasticity - Comparative Advantage and Absolute Advantage.

UNIT IV

Official Exchange Rate and Shadow Exchange Rate - Walra's Law and Terms of Trade - Trade Blocks.

UNIT V

IMF, World Bank, IDA, IFC, ADB - International Trade agreements Uruguay Round - GATT - WTO.

Practical

Producer's Surplus, Consumer's Surplus, National Welfare under Autarky and Free Trade Equilibrium with small and large country assumption Estimation of Trade Gains- Estimation of competitive and comparative measures like NPC, EPC, ERP and DRC- Estimation of Offer Curve. Elasticity- Estimation of Effect of Tariff, Export Subsidy, Producer Subsidy, Import Quota and Export Voluntary Restraints on National Welfare- Estimation of Ricardian Model - Estimation of Effect of Trade under Specific Factor Model- Estimation of trade Equilibrium under Heckscher -Ohlin model- Trade Creation and Diversion.

Suggested Readings

- Apple Yard DR & Field AI If. 1995. International Economics - Trade, Theory and Policy. Irwin, Chicago.
- Cherunilam F. 1998. International Economics. Tata McGraw Hill.
- Krugman PR & Obstfeld M. 2000. International Economics - Theory and Policy. Addison-Wesley.

AG ECON 511 : AGRICULTURAL DEVELOPMENT AND POLICIES 2+0

Objectives

To provide orientation to the students regarding the concepts and measures of economic development. To provide orientation on theories of economic growth and relevance of theories in developing countries. To make them to understand the agricultural policies and its effect on sustainable agricultural development. To make them to understand the globalization and its impact on agricultural development.

Theory

UNIT I

Development Economics - Scope and Importance - Economic development and economic growth - divergence in concept and approach - Indicators and Measurement of Economic Development - GNP as a measure of economic growth - New Measures of Welfare - NEW and MEW - PQLI - HDIGreen GNP - Criteria for under development - Obstacles to economic development - Economic and Non-Economic factors of economic growth.

UNIT II

Economic development - meaning, stages of economic development, determinants of economic growth. Theories of economic growth Ricardian growth model- The Harrod - Domar Model- The Neo classical Model of Growth - The Kaldor Model - Optimal Economic Growth - Recent Experiences of developing country economies in transition - Role of state in economic development - Government measures to promote economic development. Introduction to development planning.

UNIT III

Role of agriculture in economic / rural development - theories of agricultural development - Population and food supply - need for sound agricultural policies - resource policies - credit policies - input and product marketing policies - price policies.

UNIT IV

Development issues, poverty, inequality, unemployment and environmental degradation - Models of Agricultural Development - Induced Innovation Model - policy options for sustainable agricultural development.

UNIT V

Globalization and the relevance of development policy analysis - The dilemma of free trade? - Free trade versus Protectionism- Arguments for protection. Arguments against protection. Role of protection in Developing Countries. WTO - Agreement on Agriculture - Contradictions of free trade - proponents and opponents policies in vulnerable sectors like agriculture - Lessons for developing countries.

Suggested Readings

- Chakaravathi RM. 1986. Under Development and Choices in Agriculture. Heritage Publ., New Delhi.
- Diwett KK. 2002. Modern Economic Theory. S. Chand & Co.
- Eicher KC & Staatz 1M. 1998. International Agricultural Development. Johns Hopkins Univ. Press.
- Frank E. 1992. Agricultural Polices in Developing Countries. Cambridge Univ. Press.
- Ghatak S & Ingersent K. 1984. Agriculture and Economic Development. Select Book Service Syndicate, New Delhi.
- Jhingan ML. 1998. The Economics of Development and Planning. Vrinda Publ.
- Jules PN. 1995. Regenerating Agriculture - Polices and Practice for Sustainability and Self Reliance. Vikas Publ. House.
- Naqvi SNH. 2002. *Development Economics - Nature and Significance.* Sage Publ.

AG ECON 512 : INSTITUTIONAL ECONOMICS 1+0

Objective

The course exposes the students to the institutional problems and remedies.

Theory

UNIT I

Old and New Institutional Economics - Institutional Economics Vs Neoclassical Economics. Definition of institutions - Distinction between institutions and organizations - Institutional evolution

UNIT II

Institutional change and economic performance - national and international economic institutions. Transaction cost economics Transaction costs and the allocation of resources. Transaction costs and efficiency.

UNIT III

Free rider problem - path dependency - Interlinked transactions. Collective action and the elimination of free-rider problem - The logic of collective action and its role in reducing free rider problem - theory of Groups. Rent seeking - interest groups and policy formulation.

UNIT IV

Economic analysis of property rights- property rights regimes - private property - State Property - Common property Resources (CPRs) - public goods and club goods.

UNIT V

Special features of institutional arrangements in agriculture - Transaction costs in agriculture - Theories of agrarian institutions tenancy institutions.

Suggested Readings

- Barzel, Y. 1990. Economic Analysis of Property Rights. Cambridge Univ. Press.
- Bhardhan P. (Ed.). 1989. The Economic Theory of Agrarian Institutions. Clarendon Press, Oxford.
- Bromley DW. 1989. Economic Interests and Institutions: The Conceptual Foundations of Public Policy. Basil Blackwell, Cambridge.
- Eggertsson T. 1990. Economic Behaviour and Institutions. Cambridge Univ. Press.
- Greif A. 2006. Institutions and the Path to the Modern Economy: Lessons from Medieval Trade (Political Economy of Institutions & Decisions). Cambridge Univ. Press.
- Neelakandan S. 1992. New Institutional Economics and Agrarian Change A Primer. Indian Economic Association Trust for Research and Development, New Delhi.
- North DC. 1990. Institutions, Institutional Change and Economic Performance. Cambridge Univ. Press.
- Ostrom E. 1990. Governing the Commons: The Evolutions of Institutions for Collective Actions. Cambridge Univ. Press.

AG ECON 513 : NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS 1+1

Objectives

To introduce economics principles related to natural resource and environmental economics. To explore the concept of efficiency and the efficient allocation of natural resources. To understand the economics of why environmental problems occur. To explore the concept of

efficiency and the efficient allocation of pollution control and pollution prevention decisions. To understand the environmental policy issues and alternative instruments of environmental policies.

Theory

UNIT I

Concepts, Classification and Problems of Natural Resource Economics Economy - Environment interaction - The Material Balance principle, Entropy law- Resources Scarcity - Limits to Growth - Measuring and mitigating natural resource scarcity - Malthusian and Recardian scarcity scarcity indices - Resource Scarcity and Technical Change.

UNIT II

Theory of optimal extraction renewable resources -economic models of oil extraction - efficiency - time path of prices and extraction - Hotelling' s rule, Solow-Harwick's Rule. Theory of optimal extraction exhaustible resources -economic models of forestry and fishery.

UNIT III

Efficiency and markets - market failures - externalities - types - property rights - transaction costs - Coase's theorem and its critique - public goods common property and open access resource management - Collective action.

UNIT IV

Environmental perspectives - biocentrism, sustainability, anthropocentrism - Environmental problems and quality of environment - Sources and types of pollution -air, water, solid waste, land degradation - environmental and economic impacts - Economics of pollution control - efficient reduction in environmental pollution.

UNIT V

Environmental regulation - economic instruments - pollution charges Pigovian tax - tradable permits - indirect instruments - environmental legislations in India.

UNIT VI

Concept of sustainable development - Economic Perspective - Indicators of sustainability Relation between development and environment stress Environmental Kuznet's curve Environmental Accounting - resource accounting methods - International Environmental Issues - climate change -likely impacts -mitigation efforts and international treaties.

Practical

Exhaustible resource management -optimum rate of oil extraction. Renewable resource management - optimum harvest of Forestry/fishery. Exercise on pollution abatement -I. Exercise on pollution abatement -II. Concepts in valuing the environment. Taxonomy of valuation techniques. Productivity change method - substitute cost method - Hedonic price method - Travel cost method -Contingent valuation methods. Discount rate in natural resource management. Environment impact assessment Visit to Pollution Control Board.

Suggested Readings

- Ahmad Y, El Serafy S & Lutz E. (Eds.). 1989.Environmental Accounting for Sustainable Development. World Bank.
- Freeman AM. 1993. The Measurement of Environmental and Resource Values. Resources for the Future Press, Baltimore.
- Hackett SC. 2001. Environmental and Natural Resource Economics:Theory, Policy, and the Sustainable Society. M. E. Sharpe, Armonk, NY.
- Hartwick 1M & Olewiler ND. 1998. The Economics of Natural Resource Use. 2nd Ed. Addison-Wesley Educational Publ.
- Kerr M, Marothia DK, Katar Singh, Ramasamy C & Bentley WR. 1997. Natural Resource Economics: Theory and Applications in India. Oxford & IBH.
- Kolstad CD. 2000. Environmental Economics. Oxford Univ. Press.
- Pearce DW & Turner K. 1990. Economics of Natural Resources and the Environment. John Hopkins Univ. Press.
- Prato T. 1998. Natural Resource and Environmental Economics. Iowa State Univ. Press.
- Sankar U. 2001. Environmental Economics. Oxford Univ. Press.
- Sengupta R. 2000. Ecology and Economy, an Indian Perspective. Oxford Univ. Press.
- Tietenberg T. 2003. Environmental *and Natural Resource Economics.* 6th Ed. Addison Wesley.

AG ECON 514 : INTELLECTUAL PROPERTY MANAGEMENT 1+0

Objective

The Course Objective of the course is to create awareness about intellectual property rights in agriculture. The course deals with management of patents, trademark, geographical indications, copy rights, designs, plant variety protection and bio-diversity protection. The students will be taught on the Marketing and Commercialization of Intellectual Properties.

Theory

UNIT I

World Trade Organization- Agreement on Agriculture (AoA) and Intellectual Property Rights (IPR) - Importance of Intellectual Property Management - **IPR** and Economic growth- **IPR** and Bio diversity -Major areas of concern in Intellectual Property Management -Technology Transfer and Commercialization-Forms of different Intellectual Properties.

UNIT II

Discovery *versus* Invention - Patentability of Biological Inventions Method of Agriculture and Horticulture- procedure for patent protection:
Preparatory work. Record keeping, writing a patent document, filing the patent document - Types of patent application-patent application under the Patent cooperation treaty (PCT).

UNIT III

Plant genetic resources -Importance and conservation - Sui Generic System -Plant Varieties Protection and Farmers' Rights Act- Registration of Extant varieties - Registration and protection of New Varieties / Hybrids / Essentially Derived Varieties - Dispute prevention and settlement -Farmers' Rights.

UNIT IV

Trademark- Geographical Indications of Goods and Commodities - Copy rights-Designs - Biodiversity Protection.

UNIT V

Procedures for commercialization of technology - Valuation, Costs and Pricing of Technology- Licensing and implementation of Intellectual Properties- Procedures for commercialization - Exclusive and non exclusive marketing rights-Research Exemption and benefit sharing.

Suggested Readings

- Ganguli P. 2001. Intellectual Property Rights -Unleashing the Knowledge Economy. Tata McGraw Hill.
- Gupta AK. 2003. Rewarding Conservation of Biological and Genetic Resources and Associated Traditional Knowledge and Contemporary Grass Roots Creativity. Indian Institute of Management, Ahmedabad.
- Khan SA & Mashelkar R. 2004. Intellectual Property and Competitive Strategies in the 2yt Century. Kluwer Law International, The Hague.

AG ECON 515 : RURAL MARKETING 2+0

Objective

To provide understanding regarding issues in rural markets like marketing environment, consumer behaviour, distribution channels, marketing strategies, etc.

Theory

UNIT I

Concept and scope of rural marketing, nature and characteristics of rural markets, potential of rural markets in India.

UNIT II

Environmental factors - socio-cultural, economic and other environmental factors affecting rural marketing.

UNIT III

Rural consumer's behaviour - behavior of rural consumers and farmers; buyer characteristics and buying behaviour; Rural vis urban markets.

UNIT IV

Rural marketing strategy - Marketing of consumer durable and non-durable goods and services in the rural markets with special reference to product planning; product mix, pricing Course Objective, pricing policy and pricing strategy.

UNIT V

Product promotion - Media planning, planning of distribution channels, and organizing personal selling in rural market in India.

Suggested Readings

- Krishnamacharyulu CSG & Ramakrishan L. 2002. Rural Marketing. Pearson Edu.
- Ramaswamy VS & Nanakumari S. 2006. Marketing Management. 3rd Ed. MacMillan.
- Singh AK & Pandey S. 2005. Rural Marketing. New Age. Singh Sukhpal. 2004. Rural Marketing. Vikas Publ. House.

AG ECON 601 : ADVANCED MICRO ECONOMIC ANALYSIS 2+1

Objectives

The objective of this course is to introduce the theoretical models and applications of microeconomic theory. In particular, the basic comparative statistical techniques and the more modern duality theory will be developed and applied to the models of maximization, unconstrained and constrained utility maximization, expenditure minimization, constrained profit maximization, and cost and expenditure minimization. These mathematical structures form the basic building blocks of neoclassical economics; this course will stress the development and application of these important models. We follow a calculus rather than a graphical approach to the theory. In the subsequent sections of the course, we provide a fairly rigorous exposure to price determination under different market situations, general equilibrium theory, causes and consequences of market failure and welfare economics including the theory of public choice.

Theory

UNIT I

Theory of consumer behaviour - Duality in consumer theory - expenditure function and indirect utility function - Measurement of Income Effect and Substitution Effect. Measurement of Changes in Consumers ' Welfare Consumer's Surplus, Compensating Variation and Equivalent Variation Dynamic versions of demand functions - Integrability of demand functions. Demand Models - Linear Expenditure System, Almost Ideal Demand System. Applications of consumer theory - Household model and time allocation - Labour supply decisions by households.

UNIT II

Perfect competition - Monopoly, monopolistic competition and oligopoly. Oligopoly models - collusive and non-collusive models of oligopoly Cournot model, Chamberlin model, Stackleberg solution.

UNIT III

General equilibrium theory - Conceptual overview - General equilibrium conditions with Production and Consumption. Existence, Uniqueness and Stability of general competitive equilibrium. Walrasian general equilibrium - Mathematical derivation of conditions for general equilibrium.

UNIT IV

Market failure - Incomplete markets - Asymmetric information - PrincipalAgent problem, adverse selection and moral hazard. Externalities Network externalities - Public goods - Optimal provision of public goods.

UNIT V

Welfare Economics - Concepts, problems, approaches and limitations of Welfare Economics, Pareto conditions of maximum welfare - Criteria for social welfare - Social Welfare functions, Social versus Private costs and benefits.

Practical

Problems in consumer utility maximization - Estimation of income and substitution effects; Estimation and comparison of Consumer's surplus, equivalent variation and compensating variation. Estimation of demand models - Derivation and estimation of labour supply equations from household models comparative static analysis in consumption. Advanced problem solving in price determination under perfect competition, monopoly, oligopoly and monopolistic competition. Game theory models. Problems solving in General Equilibrium Theory and Welfare Economics. Problems in public goods provision.

Suggested Readings

- Chiang AC. 1981. Fundamental Methods of Mathematical Economics. McGraw-Hill.
- Henderson 1M & Quandt RE. Microeconomic Theory: A Mathematical Approach. McGraw-Hill.
- Koutsoyiannis A. 2003. Modern Microeconomics. The Macmillan Press.
- Kreps DM. 1990. A Course in Microeconomic Theory. Princeton Univ. Press.
- Silberberg E & Suen W. 2001. The Structure of Economics - A Mathematical Analysis. McGraw-Hill.
- Varian HR. 1992. Microeconomic Analysis. WW Norton & Co. Varian HR. 1999. Intermediate Microeconomics. Affiliated East-West Press.

AG ECON 602 : ADVANCED MACRO ECONOMICS ANALYSIS 2+0

Objective

Advanced macroeconomics course will be offered to PhD students of Agricultural Economics with the following Course Objective.
To understand the macroeconomic theory
To examine the macroeconomic Policy issues
To analyze the macroeconomic Policy implications

Theory

UNIT I

Review of Macro Economics concepts-Comparative statistics- Keynesian theory- Consumption Function and Theories of Consumption -Saving Function and Theories of Saving.

UNIT II

Theories of Investment-Savings and Investment Equality - IS - LM Framework and its demand for and Supply of Money-Monetary Policy in the static model - Inflation.

UNIT III

Stagflation and Supply side Economics - Theory of Unemployment Phillips Curve controversy - Inflation, Productivity and distribution - Fiscal policy: Effectiveness and Problems.

UNIT IV

Social Accounting Matrix Framework - General Equilibrium Analysis Neo classical Macro Economics - Stochastic Macro Economics.

UNIT V

BOP & Adjustment Policies - Foreign Exchange Policy - Foreign sector:
Capital and Current Account - Impact of WTO on Indian Economy Impact of IMF & IBRD on Indian Economy - Review of Macro Economic Policies in India.

Suggested Readings

- Diulio EA. 2006. Macroeconomics. 4th Ed. Schaums' Outlines.
- Frogen RT. 1999. Macro Economic: Theory and Policies. 6th Ed. Prentice Hall.
- Samuelson PA & Nordhaus WD. 2004. Economics. McGraw-Hill.
- Shapiro E. 1989. Macro Economic Analysis. Galgotia Publ.

AG ECON 603 : ADVANCED ECONOMETRICS 2+1

Objective

The Course Objective of the course is to impart knowledge on advanced econometric tools to the Research Scholars of agricultural economics. Training in advanced econometrics will help the Research Scholars to analyze the economic problem by applying quantitative techniques.

Theory

UNIT I

Review of classical regression model - review of hypothesis testing restrictions on parameters - single equation techniques.

UNIT II

Ordinary least squares - weighted least squares - generalized least squares -method of principal components - instrumental variables method maximum likelihood method - errors in variables, non-linearity and specification tests.

UNIT III

Dummy variables - Qualitative and truncated dependent variables - limited dependent variables - probit and logit models.

UNIT IV

Autoregressive distributed lag models - panel data, fixed and random effects models.

UNIT V

Simultaneous equation methods -identification - estimation by indirect least squares 2SLS, SURE, 3SLS.

Practical

Estimation of multiple regression model - GLS estimation methods - testing misspecification errors - Testing and Managing multicollinearity, heteroscedasticity and autocorrelation - estimation of LPM, Logit and Probit models - comparing two regressions - Chow test - estimation of distributed lag models - panel data random and fixed effects models Indirect least squares 2SLS, SURE, 3SLS, estimation of simultaneous equation models

Suggested Readings

- Greene WHo 2002. Econometric Analysis. Pearson Edu.
- Johnston J & Dinardo J. 2000. Econometric Methods. McGraw-Hill. Kelejan HH & Oates WE. 2001. Introduction to Econometrics Principles and Applications. Harper & Row.
- Maddala GS. 2002. *Econometrics.* McGraw Hill.

AG ECON 604 : ADVANCED PRODUCTION ECONOMICS 2+1

Objective

To expose the students to the concept, significance and uses of advance production economics.

Theory

UNIT I

Agricultural Production process - Relationship between farm planning and production economics-scope of agricultural production and planning methods/procedures in agro-economic research and planning.

UNIT II

Production functions, components, assumptions, properties and their economic interpretation - Concepts of homogeneity, APP, MPP, elasticities of substitution and their economic relevance - Production relations -Commonly used functional forms, nature, properties, limitations, estimation and interpretation -linear, Spillman -Cobb Douglas, quadratic, functional forms - Translog, and transcendental functional forms -CES production functional forms -Conceptual and empirical issues in specification, estimation and application of production functions- Analytical approaches to economic optimum, -Economic optimum with production function analysis - input use behaviour.

UNIT III

MRT and product relationship-cost of production -single input and multiple product decisions- Decision making with no risk - Cost curves - Principles and importance of duality theory - Correspondence of production, cost, and profit functions - Principles and derivation of demand and supply functions.

UNIT IV

Technology, input use and factor shares -effect of technology on input use. decomposition analysis-factor shares-estimation methods- Economic efficiency in agricultural production - technical, allocative and economic efficiency - measurement - Yield gaps analysis - concepts and measurement.

UNIT V

Simulation and programming techniques in agricultural production Multiple Course Objective Programming - Goal programming - Risk and uncertainty in agriculture - incorporation of risk and uncertainty in decision making - risk and uncertainty and input use level.

Practical

Estimation of different forms of production functions- Optimal input and product choice from estimated functions-Derivation of demand and supply functions and estimation-Estimation of cost function and interpretations. -Estimation of factor shares from empirical functions

estimated-Estimating production functions incorporating technology changes: Decomposition analysis and incorporation of technology-Estimation of efficiency measures -MOTAD-Simulation models for agricultural production decisions-Goal programming.

Suggested Readings

- Chambers RG. 1988. Applied Production Analysis. Cambridge Univ. Press.
- Gardner BL & Rausser GC. 2001. Handbook of Agricultural Economics. VoL IA Agricultural Production. Elsevier.
- Palanisami KP, Paramasivam & Ranganathan CR. 2002. Agricultural Production Economics: Analytical Methods and Applications. Associated Publishing Co.
- Heady EO. & Dhilon JL. *Agricultural Production Function.* Kalyani Publishers

AG ECON 605 : QUANTITATIVE DEVELOPMENT POLICY ANALYSIS 1+1

Objective

The course trains the Scholars in the art of informed decision making and helps them to appreciate the value of the analytical basis in policy decisions. They are given hands on training on the estimation and use of various criteria such as elasticities in making QDP A more meaningful. The scholars make extensive reviews to get acquainted with the analytical relevance and in drawing inferences.

Theory

UNIT I

Policy framework - goals, value, beliefs and welfare maximization. Market - Policy and State - State vs. Market - Failure of Policy - Failure of Markets - Rationale for Government Intervention. Role of Quantitative.
Policy Analysis.

UNIT II

Demand analysis for policymaking - Alternative approaches to demand analysis - Policy implications. Supply response - Alternative approaches to measurement of supply response - Nerlovian models of supply response Policy implications.

UNIT III

Household behaviour and policy analysis - Household models.

UNIT IV

Partial equilibrium analysis - Concept of reference prices - Price distortions - indicators and impact. Transaction costs - Implications for efficiency and productivity - Institutional solutions - Multi market approach to policy analysis.

UNIT V

Social Accounting -Matrices and multipliers -- Computable General Equilibrium models to assess economy wide impact of policy changes.

Practical

Review of criteria for policy evaluation - Estimation of price elasticities Review of estimation of complete demand systems - Estimation of Nerlovian supply Response model - Review of Household models Specification and estimation of household models - Partial equilibrium analysis - Input-output table - Social Accounting Matrix - Construction of a SAM - computation of Multipliers - Multi Market Analysis - Review of Computable General Equilibrium Models.

Suggested Readings

- Chenery H & Srinivasan TN. (Eds.). 1988. Hand book of Development Economics. North-Holland.
- Eicher KC & Staatz lM. 1998. International Agricultural Development. Johns Hopkins Univ. Press.
- Fischer G, Miller J & Sidney MS. (Eds.). 2007. Handbook of Public Policy Analysis: Theory, Politics and Methods. CRC Press.
- Frank E. 1992. Agricultural Polices in Developing Countries. Cambridge Univ. Press.
- Ghatak S & Ingersent K. 1984. Agriculture and Economic Development. Select Book Service Syndicate.
- Kindleberger PC. 1977. Economic Development. McGraw Hill.
- Meier MG & Stigilitz JE. 2001. Frontiers of Development Economics- the Future Perspective. Oxford Univ. Press.

❖ Sadoulet E & de Janvry A. 1995. Quantitative Development Policy Analysis. (London: John Hopkins Univ. Press.
❖ Shoven Neck R, Christian R & Mooslechner P. (Eds.). 2008. Quantitative Economic Policy Essays in Honour of Andrew Hughes Hallett.

AG ECON 606 : ADVANCED AGRICULTURAL MARKETING AND PRICE ANALYSIS 2+1

Objective

The main Course Objective of this course is to critically analyze the important marketing concepts, models, properties of agricultural commodity prices and forecasting, data collection and analysis using current software etc., in order to make them policy decisions in the field of agricultural marketing.

Theory

UNIT I

Importance of market analysis in the agricultural system - types of marketing- advantages and disadvantages - quantitative estimation - the distinguishing characteristics and role of agricultural prices - data sources for agricultural products and prices - softwares used in market analysis.

UNIT II

Role of various formal institutions in agricultural marketing - and functions - measuring their efficiency - public - private partnership - institutional arrangements. Successful case studies.

UNIT III

Multi market estimation, supply response models. Market integration and price transmission - supply / value chain management. GAP analysis. Current trends in information in the changing agrifood system.

UNIT IV

Agricultural commodity marketing - spot and futures- marketing of derivatives-speculation, hedging, swap, arbitrage etc. commodity exchanges - price discovery and risk management in commodity markets- Regulatory mechanism of futures trading.

UNIT V

Lag operators and difference equations; stationary and stochastic processes; **UNIT** roots and cointegration; conditional heteroscedasticity: ARCH and GARCH models - forecast evaluation; methods of forecasting. price indices and econometric estimation and simulation.

Practical

Estimation of demand/ supply forecasting, supply chain / value chain analysis for different commodities - Commodity modelsmulti market estimation- time series analysis - market integration studies- price discovery price volatility estimation - commodity price forecasting using econometric softwares.

Suggested Readings

❖ Perris IN. 1998. Agricultural Prices and Commodity Market Analysis. McGraw-Hill.
❖ Goodwin JW. 1994. Agricultural Price Analysis and Forecasting. Wiley.
❖ Hallam D. 1990. Econometric Modeling of Agricultural Commodity Markets. New Routledge.
❖ Martimort D. (Ed.). 1996. Agricultural Markets: Mechanisms, Failures, and Regulations. Elsevier.
❖ Schrimper RA. 2001. Economics of Agricultural Markets. Pearson. Timmer CPo 1986. Getting Prices Right. Cornell University Press.
❖ Tomek WG & Robinson KL. 2003. Agricultural Product Prices. 4th Ed. Cornell University Press.

AG ECON 607 : COMMODITY FUTURES TRADING 2+0

Objective

This course is aimed at providing the basic understanding and the mechanics and value of futures markets for speculators and hedgers which in turn will serve as price risk management activities of agribusiness firms.

Theory

UNIT I

History and Evolution of commodity markets - Terms and concepts: spot, forward and futures Markets - factors influencing spot and future markets. Speculatory mechanism in commodity futures.

UNIT II

Transaction and settlement - delivery mechanism - role of different agents trading strategies - potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets.

UNIT III

Risk in commodity trading, importance and need for risk management measures - managing market price risk: hedging, speculation, arbitrage, swaps - pricing and their features.

UNIT IV

Important global and Indian commodity exchanges - contracts traded special features - Regulation of Indian commodity exchanges - FMC and its role.

UNIT V

Fundamental V s Technical analysis - construction and interpretation of charts and chart patterns for analyzing the market trend - Market indicators - back testing. Introduction to technical analysis software - analyzing trading pattern of different commodity groups.

Suggested Readings

- Kaufman PJ. 1986. The Concise Handbook of Futures Markets. John Wiley & Sons.
- Leuthold RM, Junkus JC & Cordier JE. 1989. The Theory and Practice of Futures Markets. Lexington Books.
- Lofton T. 1993. Getting Started in Futures. 3rd Ed. John Wiley & Sons.
- Purcell WD. 1991. Agricultural Futures and Options: Principles and Strategies. Macmillan Publ.
- Wasendorf RR & McCafferty. 1993. *All about Commodities from the Inside Out.* McGraw-Hill.

AG ECON 608 : NATURAL RESOURCE MANAGEMENT 1+1

Objectives

This is an applied economics course that focuses on the economic analysis of natural resources, and seeks to identify and solve natural resource management problems via mathematical approach using dynamic optimization techniques. During the course, we will encounter bioeconomic models of natural resources including the classic and more recent forestry and fisheries models, models of land and water use and extraction of non-renewable resources (such as from a mineral deposit). We will focus on intuition and understanding of the economic analysis rather than complicated mathematical models in this class. That said, natural resource problems are inherently dynamic, so some mathematical modeling of biophysical and economic processes will be required. Using computers as an aid to understanding the models will be an important part of the class. The primary tool will be Microsoft Excel, which is the easiest introduction to computational optimization and graphical representation of the results.

Theory

UNIT I

Natural resources - definition - characteristics and classification. Stock dynamics of renewable and non-renewable resources. Equation of motion for renewable and non-renewable resources. Fundamental equation of renewable resources.

UNIT II

Growth curves of fishery and forest resources. The role of time preference in natural resource use. Simple two-period model of optimal use of renewable and non-renewable resources. Advanced models of optimal resource use - Static V/s. dynamic efficiency in natural resource use Applications of dynamic programming and optimal control.

UNIT III

Economics of groundwater use - optimal extraction of groundwater. Analytical and numerical solutions for optimal inter-temporal allocation of natural resources. Optimal harvesting of single rotation and multiple rotation forests. Optimal management of fishery.

UNIT IV

Property rights in natural resources and their implication for conservation and management of

natural resources. -Management of common property natural resources - Institutional arrangements for conservation and management of common pool fishery, groundwater and forestry resource.

UNIT V

Resource scarcity - Natural resource degradation - Poverty and resource degradation - Natural resource accounting - Pricing and valuation of natural resources - Natural resources policy.

Practical

Derivation of the fundamental equation of renewable resources-Estimation of growth curves and stock dynamics for fishery and forestry resources. Simple two period problem of optimal resource use - Numerical solution for simple two-period model of dynamic efficiency in natural resource extraction. Multi-period dynamic efficiency - Using Excel Solver in solving dynamic natural resource harvesting problems. Using analytical solution procedures for solving natural resource management problems Optimal control.

Suggested Readings

- Baland J-M & Platteau JP. 1996. Halting Degradation of Natural Resources: Is There a Role for Rural Communities? Clarendon Press and FAa.
- Carlson GA, Miranowski J & Zilberman D. 1998. Agricultural and Environmental Resource Economics. Oxford Univ. Press.
- Chiang AC. 1992. Elements of Dynamic Optimization. Waveland Press. Clark CWo 1976. Mathematical Bioeconomics: The Optimal Management of Renewable Resources. John Wiley and Sons.
- Conrad JM & Clark CWo 1997. Natural Resource Economics: Notes and Problems. Cambridge Univ. Press.
- Conrad JM. 1999. Resource Economics. Cambridge University Press. Fisher AC. 1981. Resource and Environmental Economics. Cambridge Univ. Press.
- Prato T. 1998. Natural Resource and Environmental Economics. Iowa State Univ. Press.
- Sterner T. 2003. Policy Instruments for Environmental and Natural Resource Management. Resources for the Future, Washington DC.

AG ECON 609 : ENVIRONMENTAL ECONOMICS 2+1

Objective

The main objective of this course is to provide an advanced treatment of the economic theory of environmental management and policy, externalities and market and non-market approaches to environmental improvement. Topics in economic growth and environmental problems, poverty and environmental degradation, conservation and sustainable economic growth, intergenerational and global environmental problems, policy issues in environmental regulation and management will be covered at a sufficient depth so as to equip the students with the recent developments in the field.

Theory

UNIT I

Environmental pollution as a consequence of market failure - Causes and consequences of market failure - Externalities - Public goods and externalities - Economics of pollution - Private vs. Social cost of environmental pollution - Property rights, environment and development - Theory of environmental policy.

UNIT II

Environmental cost benefit analysis - Environmental impact assessment techniques - Non-market valuation of environmental resources (WTP / WTA) - Environment, market and social welfare.

UNIT III

Economic growth and environmental cost - Growth oriented economic policies and their environmental impacts - Population and environmental quality - poverty and environmental degradation - Sustainable development - Indicators of sustainable development - Issues in sustainable development.

UNIT IV

Environment, ecology and environmental accounting - Environmental pollution with respect to water and air - Land and forest resources related environmental pollution - Coastal externalities - Urbanization and environment - Basic approaches to environmental policy (Tax,

subsidy, pollution permits etc.) Green taxes - Political economy of environmental regulation and management.

UNIT V

Transboundary environmental problems - Economics of global warming, climate change and emission trading - Environment, international trade and development.

Practical

Contemporary global environmental issues, movement, policies, programmes, laws and other regulatory mechanisms. Criteria for evaluating the environment related projects and review of Environmental Impact Assessment (EIA) techniques - Recreation demand models of environmental valuation - Contingent valuation techniques.Environmental Resource Accounting Techniques - Discussion on the techniques dealing with air pollution and review of case studies on air pollution and its impacts - forest environment and wild life conservation. - Green GDP and Green house insurance - Practical considerations and comparison of instruments of environmental policy - Non-point source pollution control methodologies - Environment in macroeconomic modeling - Meta-analysis, economic valuation and environmental economics - Multi-criteria methods for quantitative, qualitative and fuzzy evaluation problems related to environment - Input output analysis, technology and the environment - Computable general equilibrium models for environmental economics and policy analysis.

Suggested Readings

- Carlson GA, Miranowski J & Zilberman D. 1998. Agricultural and Environmental Resource Economics. Oxford Univ. Press.
- Hanley N, Shogren J & White B. 2007. Environmental Economics in Theory and Practice. Palgrave, London.
- Kolstad C. 1999. Environmental Economics. Oxford Univ. Press.
- Prato T. 1998. Natural Resource and Environmental Economics. Iowa State Univ. Press.
- Sterner T. 2003. Policy Instruments for Environmental and Natural Resource Management. Resources for the Future. The World Bank and SIDA.

AGRICULTURAL EXTENSION

AG.EXTN 501 : DEVELOPMENT PERSPECTIVES OF EXTENSION EDUCATION 1+1

Objective

The course is intended to orient the students with the concept of extension education and its importance in Agriculture development and also to expose the students with various Rural development programmes aimed at poverty alleviation and to increase employment opportunites and their analysis. Besides, the students will be learning about the new innovations being brought into the Agricultural Extension in India.

Theory

UNIT I

Extension Education – Meaning, objectives, concepts, principles and philosophy, critical analysis of definitions – Extension Education as a Profession – Adult Education and Distance Education.

UNIT II

Pioneering Extension efforts and their implications in Indian Agricultural Extension – Analysis of Extension systems of ICAR and SAU – State Departments Extension system and NGOs – Role of Extension in Agricultural University.

UNIT III

Poverty Alleviation Programmes – SGSY, SGRY, PMGSY, DPAP, DDP, CAPART – Employment Generation Programmes – NREGP, Women Development Programmes – ICDS, MSY, RMK, Problems in Rural Development.

UNIT IV

Current Approaches in Extension: Decentralised Decision Making, Bottom up Planning, Farming System Approach, Farming Situation Based Extension, Market – Led – Extension, Farm Field School, ATIC, Kisan Call Centres, NAIP.

Practical

Visit to Gram Panchayat to study on-going Rural Development Programmes, Visit to KVK, NGO and Extension centers of State Agricultural University and State Departments, Bottom up planning, Report preparation and presentations.

Suggested Readings

- Chandrakandan KM, Senthil Kumar & Swatilaxmi. PS. 2005. Extension Education What? And What Not ? RBSA Publ.
- Gallagher K. 1999. Farmers Field School (FFS) – A Group Extension Process based on Non-Formal Education Methods. Global EPM Facility, FAO.
- Ganesan R, Iqbal IM & Anandaraja N. 2003. Reaching the Unreached:Basics of Extension Education. Associated Publishing Co.
- Jalihal KA & Veerabhadraiah V. 2007. Fundamentals of Extension Education and Management in Extension. Concept Publ.
- Khan PM. 2002. Textbook of Extension Education. Himalaya Publ.
- Ray GL. 2006. Extension Communication and Management. Kalyani Publ.
- Van Den Ban AW & Hawkins HS. 1998. Agricultural Extension.2nd Ed. CBS.
- Viswanathan M. 1994. *Women in Agriculture and Rural Development*. Printwell Publ.

AG.EXTN 502 : DEVELOPMENT COMMUNICATION AND INFORMATION MANAGEMENT 2+1

Objective

In this course, students will learn about the concept, meaning and process of communication and various methods and modern media of communication.Besides, the students will also learn the information management and journalistic writing of various information materials and also study their readability.

Theory

UNIT I

Communication process – concept, elements and their characteristics – Models and theories of communication – Communication skills– fidelity of communication, communication competence and empathy, communication effectiveness and credibility, feedback in communication, social networks and Development communication – Barriers in communication, Message – Meaning, dimensions of a message, characteristics of a good message, Message treatment and effectiveness, distortion of message.

UNIT II

Methods of communication – Meaning and functions, classification. Forms of communication – Oral and written communication, Non-verbal communication, interpersonal communication, organizational communication. Key communicators – Meaning, characteristics and their role in development.

UNIT III

Media in communication – Role of mass media in dissemination of farm technology, Effect of media mix for Rural People. Modern communication media – Electronic video, Tele Text, Tele conference, Computer Assisted Instruction, Computer technology and its implications.

UNIT IV

Agricultural Journalism as a means of mass communication, Its form and role in rural development, Basics of writing – News stories, feature articles, magazine articles, farm bulletins and folders. Techniques of collection of materials for news stories and feature articles; Rewriting Art of clear writing, Readability and comprehension testing procedures; photo journalism, communicating with pictures, Radio and TV Journalism, Techniques of writing scripts for Radio and TV.

Practical

Processes of printing extension literature, news collection and interniew, writing for farm magazines and newspapers, Extension publications including folder, booklets, circular letter

and wall newspaper, preparation of radio and T V scripts and success story. Communication through pictures, designing cover page of magazines and folders, Visit to different printing units.

Suggested Readings

- Dahama OP & Bhatnagar OP. 2005. Education and Communication for Development. Oxford & IBH.
- Grover I, Kaushik S, Yadav L & Varma SK. 2002. Communication and Instructional Technology. Agrotech Publ. Academy.
- Jana BL & Mitra KP. 2005. Farm Journalism. Agrotech Publ. Academy.
- Ray GL. 2006. Extension Communication and Management. Kalyani Publ.
- Rayudu CS.2002. Communication. Himalaya Publ. House.
- Reddy AA. 1987. Extension Education. Sree Lakshmi Press,
- Bapatla. Sandhu AS. 2004. Textbook on Agricultural Communication Process and Methods. Oxford & IBH.

AG.EXTN 503 : DIFFUSION AND ADOPTION OF INNOVATIONS 2+1

Objective

The students will learn how the agricultural innovations spread among the farmers in the society by getting into the insights of diffusion concept and adoption process, stages of adoption and innovation decision process, adopter categories and their characteristics, opinion leaders and their characteristics, attributes of innovations, and factors influencing adoption. In addition, the students would be learning various concepts related to diffusion and adoption of innovations.

Theory

UNIT I

Diffusion – concept and meaning, elements; traditions of research on diffusion; the generation of innovations; innovation-development process; tracing the innovation-development process, converting research into practice.

UNIT II

The adoption process- concept and stages, dynamic nature of stages, covert and overt processes at stages, the innovation-decision process – a critical appraisal of the new formulation.

UNIT III

Adopter categories – Innovativeness and adopter categories, adopter categories as ideal types, characteristics of adopter categories; Perceived attributes of Innovation and their rate of adoption, factors influencing rate of adoption.

UNIT IV

Diffusion effect and concept of over adoption, opinion leadership- measurement and characteristics of opinion leaders, monomorphic and polymorphic opinion leadership, multi-step flow of innovation; concepts of homophily and heterophily and their influence on flow of innovations; Types of innovation-decisions – Optional, Collective and Authority and contingent innovation decisions; Consequences of Innovation-Decisions – Desirable or Undesirable, direct or indirect, anticipated or unanticipated consequences; Decision making – meaning, theories, process, steps, factors influencing decision – making.

Practical

Case studies in individual and community adoption process, content analysis of adoption studies, Identification of adopter categories on a selected technology, study of attributes of current farm technologies, Identification of opinion leaders, Sources of information at different stages of adoption on a selected technology, study of factors increasing or retarding the rate of adoption, presentation of reports on adoption and diffusion of innovations.

Suggested Readings

- Dasgupta. 1989. Diffusion Agricultural Innovations in Village India. Wiley Eastern.
- Jalihal KA & Veerabhadraiah V. 2007. Fundamentals of Extension Education and Management in Extension. Concept Publ. Co.
- Ray GL. 2005. Extension Communication and Management. Kalyani Publ.
- Reddy AA. 1987. Extension Education. Sree Lakshmi Press,

❖ Bapatla. Rogers EM. 2003. Diffusion of Innovations. 5th Ed. The Free Press, New York.

AG.EXTN 504 : RESEARCH METHODS IN BEHAVIOURAL SCIENCE 2+1

OBJECTIVE

This course is designed with a view to provide knowledge and skills in methods of behavioural sciences research and student will learn the Statistical Package for Social Sciences (SPSS) for choosing appropriate statistics for data analysis.

Theory

UNIT I

Research – Meaning, importance, characteristics. Behavioural sciences research – Meaning, concept and problems in behavioural sciences research. Types and methods of Research – Fundamental, Applied and Action research, Exploratory, Descriptive, Diagnostic, Evaluation, Experimental, Analytical, Historical, Survey and Case Study. Review of literature – Need, Search Procedure, Sources of literature, Planning the review work. Research problem – Selection and Formulation of research problem and guiding principles in the choice of research problem, Factors and criteria in selection of research problem, statement of research problem and development of theoretical orientation of the research problem.

UNIT II

Objectives – Meaning, types and criteria for judging the objectives. Concept and Construct – Meaning, role of concepts in research and Conceptual frame work development in research. Variable – Meaning, types and their role in research. Definition – Meaning, characteristics of workable definitions, types and their role in research. Hypothesis – Meaning, importance and functions of hypothesis in research, Types of hypothesis, linkages, sources, problems in formulation and criteria for judging a workable hypothesis. Measurement – Meaning, postulates and levels of measurement, Use of appropriate statistics at different levels of measurement, criteria for judging the measuring instrument and importance of measurement in research. Validity – Meaning and methods of testing. Reliability – Meaning and methods of testing. Sampling – Universe, Sample and Sampling-Meaning, basis for sampling, advantages and limitations, size and factors affecting the size of the sample and sampling errors – Methods of elimination and minimizing, Maximincon Principle, Sampling – Types of sampling and sampling procedures.

UNIT III

Research Designs – Meaning, purpose and criteria for research design, Types, advantages and limitations of each design. Experimental design – Advantages and limitations. Data Collection devices - Interview – Meaning, purpose, types, techniques of interviewing and advantages and limitations. Enquiry forms and Schedules – Meaning, types of questions used, steps in construction and advantages and limitations in its use. Questionnaires – Meaning, difference between schedule and questionnaire, types of questions to be used, pre – testing of the questionnaires or schedules and advantages and limitations. Check lists – Meaning, steps in construction, advantages and limitations in its use. Rating scales – Meaning, types, limits in construction, advantages and limitations in its use. Observation – Meaning, types, tips in observation, advantages and limitations in its use. Case studies – Meaning, types, steps in conducting, advantages and limitations in its use. Social survey – Meaning, objectives, types and steps in conducting, advantages and limitations.

UNIT IV

Data processing – Meaning, coding, preparation of master code sheet, analysis and tabulation of data, Statistical Package for Social Sciences (SPSS) choosing appropriate statistics for data analysis based on the level of measurement of variables. Report writing – Meaning, guidelines to be followed in scientific report writing, References in reporting.

Practical

Selection and formulation of research problem - Formulation of objectives and hypothesis-Selection of variables based on objectives-Developing the conceptual framework of research. Operationally defining the selected variables-Development of data collection devices.-Testing the validity and reliability of the data collection instruments.- Pre-testing of the data collection instrument-Techniques of interviewing and collection of data using the data collection instruments-Data processing, hands on experiences on SPSS, coding, tabulation and analysis. Formulation of secondary tables based on objectives of research.Writing report,

Writing of thesis and research articles-Presentation of reports.

Suggested Readings

- Chandrakandan K, Venkatapirabu J, Sekar V & Anand Kumar V. 2000. Tests and Measurements in Social Research. APH Publ.
- Kerlinger FN. 1973. Foundations of Behavioural Research. Holt Rhinehart. Kothari CR.1984. Research Methodology, Methods and Techniques. Chaitanya Publ. House.
- Krishnaswami OR & Ranganatham M. 2005. Methodology of Research in Social Sciences. Himalaya Publ. House.
- Mulay S & Sabaratnam VE.1983. Research Methods in Extension Education. Manasavan.
- Ranjit Kumar. 1999. Research Methodology - A Step by Step Guide for Beginners. Sage Publ.
- Ray GL & Sagar Mondal. 1999. Research methods in Social Sciences and Extension Education. Naya Prokash.
- Wilkinson TS & Bhandarkar PC.1993. Methodology and Techniques of Social Research. Himalaya Publ.Home.

AG.EXTN 505 : E- EXTENSION 2+1

Objective

Students will gain knowledge and skills in understanding the concepts of Information and communication technologies and how these ICT tools can be used for Agricultural Extension. Besides, he studies various ICT projects which are successful in delivering the services to the clientele fulfilling the objective of Transfer of Technology i.e. Reaching the unreached.

Theory

UNIT I

ICTs- Concept, definition, tools and application in extension education. Reorganizing the extension efforts using ICTs, advantages, limitations and opportunities.

UNIT II

ICTs projects, case studies in India and developing world. Different approaches (models) to ICTs. ICT use in field of extension- Expert systems on selected crops and enterprises; Self learning CDs on package of practices, diseases and pest management, Agricultural web sites and portals related crop production and marketing etc.

UNIT III

Community Radio, Web, Tele, and Video conferencing. Computer Aided Extension. Knowledge management, Information kiosks, Multimedia. Online, Offline Extension. Tools-Mobile technologies, e-learning concepts.

UNIT IV

ICT Extension approaches-pre-requisites, information and science needs of farming community. Need integration. Human resource information. Intermediaries. Basic e-extension training issues. ICT enabled extension pluralism. Emerging issues in ICT.

Practical

Agril.content analysis of ICT Projects. Handling of ICT tools. Designing extension content. Online extension service. Project work on ICT enabled extension. Creation of extension blogs. Visit to ICT extension projects.

Suggested Readings

- Batnakar S & Schware R. 2000. Information and Communication Technology in Development- Cases from India. Sage Publ.
- Meera SN. 2008. ICTs in Agricultural Extension: Tactical to Practical. Ganga-Kaveri Publ. House. JangamWadiMath, Varanasi.
- Willem Zip. 1994. Improving the Transfer and Use of Agricultural Information - A Guide to Information *Technology*. The World Bank, Washington.

AG.EXTN 506 : ENTREPRENEURSHIP DEVELOPMENT AND MANAGEMENT IN EXTENSION 2+1

Objective

The first part of the course is intended to provide overall picture of planning and development of enterprises for extending sustainable livelihoods for rural people. The second part of the

course is structured to help the students to gain knowledge and skills in different concepts and techniques of management in extension organizations.

Theory

UNIT I

Entrepreneurship – Concept, characteristics, Approaches, Theories, Need for enterprises development. Agri – entrepreneurship – Concept, characteristics, Nature and importance for sustainable Livelihoods. Traits of entrepreneurs – Risk taking, Leadership, Decision making, Planning, Organising, Coordinating and Marketing, Types of Entrepreneurs. Stages of establishing enterprise – Identification of sound enterprise, steps to be considered in setting up an enterprise, feasibility report, product selection, risk and market analysis, legal requirements. Project Management and Appraisal – Market, Technical, Financial, Social Appraisal of Projects.

UNIT II

Micro enterprises – Profitable Agri enterprises in India – Agro Processing, KVIC industries. Micro financing – meaning, Sources of Finance, Banks, Small scale industries development organizations. Marketing for enterprises – Concept, planning for marketing, target marketing, Competition, market survey and strategies, Product sales and promotion. Gender issues in entrepreneurship development – Understanding gender and subordination of women, Gender as a development tool, Policy approaches for women entrepreneurship development. Success and Failure stories for enterprises – Issues relating to success and failure of enterprises – Personal, Production, Finance, Social, Marketing.

UNIT III

Management – Meaning, concept, nature and importance, Approaches to management, Levels of management, Qualities and skills of a manager. Extension Management – Meaning, Concept, Importance, Principles of management, Classification of Functions of Management. Planning – Concept, Nature, Importance, Types, Making planning effective. Change Management – factors, process and procedures. Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions. Organizing – Meaning of Organization, Concept, Principles, Organizational Structure, Span of Management, Departmentalization, Authority and responsibility, Delegation and decentralization, line and staff relations.

UNIT IV

Coordination – Concept, Need, Types, Techniques of Coordination. Interpersonal relations in the organization. Staffing – Need and importance, Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development – Performance appraisal – Meaning, Concept, Methods. Direction – Concept, Principles, Requirements of effective direction, Giving orders, Techniques of direction. Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles. Organizational Communication – Concept, Process, Types, Net Works, Barriers to Communication. Managing work motivation – Concept, Motivation and Performance, Approaches to motivation. Supervision – Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision. Managerial Control – Nature, Process, Types, Techniques of Control, Budgeting, Observation, PERT and CPM, MIS.

Practical

Field visit to Successful enterprises-Study of Characteristics of Successful entrepreneurs Development of Project Proposal -Case Studies of Success / Failure enterprises-Exercise on Market Survey-Field visit to Financial institutions-Simulated exercise to understand management process-Field visit to extension organizations to understand the functions of management -Group exercise on development of short term and long term plan-Simulated exercise on techniques of decision making-Designing organizational structure -Group activity on leadership development skills.

Suggested Readings

- Gupta CB. 2001. Management Theory and Practice. Sultan Chand & Sons.
- Indu Grover. 2008. Handbook on Empowerment and Entrepreneurship. Agrotech Public Academy.
- Khanka SS. 1999. Entrepreneurial Development. S. Chand & Co.

- Singh D. 1995. Effective Managerial Leadership. Deep & Deep Publ.
- Tripathi PC & Reddy PN. 1991. Principles of Management. Tata McGraw Hill.
- Vasanta Desai. 1997. *Small Scale Industries and Entrepreneurship*. Himalaya Publ. House.

AG.EXTN 507 : HUMAN RESOURCE DEVELOPMENT (HRD) 2+1

Objective

To orient the students about key concepts importance, scope & conceptual frame work, growth & development of Human Resource Development, Subsystems of Human Resource Development for extension organization and process of HRD.

Theory

UNIT I

Human Resource Development – Definition, Meaning, Importance, Scope and Need for HRD; Conceptual frame work, inter disciplinary approach, function systems and case studies in HRD; HRD Interventions – Different Experiences; Selection, Development & Growth- Selection, Recruitment, Induction Staff Training and Development, Career planning; Social and Organizational Culture: Indian environment perspective on cultural process and social structure, society in transition; Organizational and Managerial values and ethics, organizational commitment ; Motivation productivity - job description – analysis and evaluation; Performance Appraisal.

UNIT II

Human Resource management: Collective bargaining, Negotiation skills; Human Resource Accounting (HRA): What is HRA? Why HRA? Information Management for HRA and Measurement in HRA; Intra personal processes: Collective behaviour, learning, and perception ; Stress and coping mechanisms; Inter-Personal Process, Helping Process – communication and Feedback and interpersonal styles; Group & Inter group process: group information and group processes; Organizational communication, Team building Process and functioning, Conflict management, Collaboration and Competition; HRD & Supervisors: Task Analysis; Capacity Building – Counseling and Mentoring; Role of a Professional Manager: Task of Professional Manager – Responsibility of Professional Manager; Managerial skills and Soft Stills required for Extension workers; Decision Making: Decision Making models, Management by Objectives; Behavioural Dynamics :Leadership styles – Group dynamics.

UNIT III

Training – Meaning, determining training need and development strategies – Training types, models, methods and evaluation; Facilities for training – Trainers training – techniques for trainees participation; Research studies in training extension personnel; Main issues in HRD: HRD culture and climate – organizing for HRD – emerging trends and Prospective.

Practical

Visit to different training organizations to review on going activities & facilities; Analysis of Training methods followed by training institutions for farmers and extension workers Studies on evaluation of training programmes; Study of HRD in organization in terms of performance, organizational development, employees welfare and improving quality of work life and Human resource information, Presentation of reports.

Suggested Readings

- Agochiya D. 2002. Every Trainer's Handbook. Sage Publ.
- David Gross. 1997. Human Resource Management - The Basics. TR Publ. Davis Keth & Newston W John 1989. Human Behaviour at Work. 8th Ed. McGraw-Hill.
- Hersey Paul & Balanchard H Kenneth. 1992. Management of Organizational
- Behaviour Utilizing Human Resource. 5th Ed. Prentice-Hall of India.
- Knoontz Harold & Weihhrich Heinz 1990. Essentials of Management. 5th Ed. McGraw-Hill.
- Lynton RP & Pareek U. 1993. Training for Development. DB. Taraporewale Sons & Co.
- Punna Rao P & Sudarshan Reddy M. 2001. Human Resource Development Mechanisms for Extension Organization. Kalyani Publ.
- Rao TV. 2003. Readings in Human Resource Development. Oxford Publ. Co.
- Silberman Mel. 1995. Active Training. Press Johnston Publ. Co., New Delhi.
- Singh RP. 2000. Management of Training Programmes. Anmol Publ.
- Subba Rao P. 2005. Management & Organizational Behaviour. Himalaya Publ. House.

- Sundaram RM, Gupta V, George SS. 2006. Case Studies in Human Resource Management. ICFAI, Hyderabad.
- Tripati & Reddy. 2004. Principles of Management. Tata McGraw-Hill. Wayne MR & Robert MN. 2005. *Human Resource Management*. International Ed. Pearson Prentice Hall.

AG.EXTN 508 : VISUAL COMMUNICATION 2+1

Objective

This course is intended to give a clear perspective about the importance of visuals and graphics in communication. The course starts with the delineating about the characteristics of visuals and graphics followed by its main functions, theories of visual perception and its classification and selection. Further, the course deals with the designing the message, graphic formats and devices and presentation of data. It makesthe students to understand, prepare and present the scientific data effectively by using low cost visuals. The course also exposes the students to various Digitized video material in multimedia and also enable to design visuals for print, TV and know-how about scanning of visuals.

Theory

UNIT I

Role of visuals & graphics in Communication. Characteristics of visuals & graphics. Functions of visuals and graphics. Theories of visual perception. Classification and selection of visuals.

UNIT II

Designing message for visuals, Graphic formats and devices. Presentation of Scientific data. Principles and procuction of low cost visuals.

UNIT III

Photographs- reprographic visuals. PC based visuals. Degitized video material in multimedia production. Designing visuals for print and TV and video.

UNIT IV

Pre-testing and evaluation of visuals. Scanning of visuals.

Practicals

Preparation of low cost projected and Non-Projected visuals. Designing and layout of charts, posters, flash cards etc. Power point presentations. Generating computer aided presentation graphics. Scanning and evaluation of visuals.

Suggested Readings

- Bhatia A. 2005. Visual Communication. Rajat Publications, New Delhi. Edgar Dale 1970. Audio Visual methods in Teaching. Holt, Rinehart & Winston.
- James WB, Richard BL, Fried F Harcleroad. 1952. A.V. Instructional Material & Methods. Mc.Graw Hill.
- Reddy YN. 1998. Audio Visual Aids in Teaching, Training and Extension. Haritha Publ. House, Hyderabad.

AG.EXTN 509 : PARTICIPATORY METHODS FOR TECHNOLOGY DEVELOPMENT AND TRANSFER 1+1

Objective

This course is intended to orient the students with the key concepts, principles process of different participatory approaches for technology development and transfer and also to expose the students with various participatory tools and techniques like space related, time related, relation oriented methods. Besides the students will be learning the preparation of action plans participatory monitoring and evaluation.

Theory

UNIT I

Participatory extension – Importance, key features, principles and process of participatory approaches; Different participatory approaches (RRA, PRA, PLA, AEA, PALM, PAR, PAME, ESRE, FPR) and successful models.

UNIT II

Participatory tools and techniques. Space Related Methods : village map (social & resource), mobility services and opportunities map and transect; Time related methods : time line, trend analysis, seasonal diagram. Daily activity schedule, dream map; Relation oriented

methods : cause and effect diagram (problem tree), impact – diagram, well being ranking method, Venn diagram, matrix ranking, livelihood analysis.

UNIT III

Preparation of action plans, concept and action plan preparation; Participatory technology development and dissemination; Participatory planning and management, phases and steps in planning and implementation aspects; Process monitoring, participatory evaluation.

Practical

Simulated exercises on space related methods, time related method and relation oriented methods; Documentation of PTD and dissemination; Preparation of action plan; Participatory monitoring and evaluation of developmental programmes.

Suggested Readings

- Adhikary. 2006. Participatory Planning and Project Management in Extension Science. Agrotech Publ. Academy.
- Mukharjee N. 2002. Participatory Learning and Action. Concept Publ. Co.
- Singh BK. 2008. PRA/PLA and Participatory Training. Adhyayan Publ. & Distr.
- Somesh Kumar. 2002. *Methods for Community Participation*. Vistaar Publ.

AG.EXTN 510 : GENDER SENSITIZATION FOR DEVELOPMENT 1+1

Objective

In this course the students will learn about an overview of the concept of gender and gender balance on development and develop skills of identifying gender roles, rights, responsibilities and relationships on development. Besides the students will also learn the attitudinal change to internalize gender equity concerns as fundamental human rights and also enhance the capability for identifying and analyzing gender issues in agriculture and allied sectors.

Theory

UNIT I

Gender concepts, issues and challenges in development; Gender roles, gender balance, status, need and scope; Gender analysis tools and techniques.

UNIT II

National policy for empowerment of women since independence; Developmental programmes for women; Gender mainstreaming in agriculture and allied sectors –need and relevance; Gender budgeting – A tool for empowering women.

UNIT III

Women empowerment –Dimensions; Women empowerment through SHG approach; Women entrepreneurship and its role in economic development; Public Private Partnership for the economic empowerment of women; Building rural institution for women empowerment; Women human rights ; Action plans for gender mainstreaming.

Practical

Visits to rural institutions of women for studying in the rural institutions engaged in Women empowerment; Visits to entrepreneurial unit of women for studying the ways and means of establishing entrepreneurship units for Women and their development and also SWOT analysis of the Unit; Visit to Center for women development - NIRD to study the different activities related to projects and research on gender; Visit to gender cell, Office of the Commissioner and Director of Agriculture, Hyderabad, to study the mainstreaming of gender concerns and gender budget of the department.

Suggested Readings

- Grover I & Grover D. 2002. Empowerment of Women. Agrotech Publ. Academy.
- Porter F, Smyth I & Sweetman C.1999. Gender Works: Oxfarm Experience in Policy and Practice. Oxfarm Publ.
- Raj MK. 1998. Gender Population and Development. Oxford Univ. Press.
- Sahoo RK & Tripathy SN. 2006. SHG and Women Empowerment. Anmol Publ.
- Sinha K. 2000. Empowerment of Women in South Asia. Association of Management Development Institution in South Asia, Hyderabad.
- Thakur Joshi S. 1999. Women and Development. Mittal Publ.
- Vishwanathan M. 1994. *Women in Agriculture & RD*. Rupa Books.

AG.EXTN 511 : PERSPECTIVES OF DISTANCE EDUCATION 1+1

Objective

The course is intended to orient the students with the concept of Distance Education, Characteristics of Distance Education, Evolution, Methods of Distance Education, Different Approaches in Planning Distance Education, Educational Technology in Distance Education, Management of Resources for distance education, Strategies for maximizing the reach and programme evaluation and quality assessment.

Theory

UNIT I

Distance Education – Introduction Meaning, Concept, Philosophy and its work ethics, characteristics of Distance Education – Evolution and Historical view of Distance Education – Theory Methodology, and Epistemology. Dimensions of Distance Education, Scope and difficulties. Open Education – Non-formal Education, Continuing Education, Education by correspondence.

UNIT II

Forms and systems of Distance and Open Education, Modes of Teaching and Learning in Distance Education, Methods of Distance Education, Significance of Distance Education in Teacher Education.

UNIT III

Planning Distance Education – A Systems Approach Student Learning – Course Planning, The target groups – Barriers to learning in Distance Education – Planning and Management of Networked Learning.

UNIT IV

Educational Technology is Distance Education Application of information and Educational Technologies in Distance Education, Development of Course and Course material, Management of resources, processes, Forms of Instructional material in Distance Education and Media Development and Production in Distance Education - Video Classroom Strategy in Distance Education – Strategies for maximizing the reach – services to students, programme Evaluation -performance indicators and Quality Assessment.

Practical

Visit to the University which is implementing the Distance Education Programmes. Detailed Study of their programme in relation to Educational Technology, Methodology, Curriculum Development, Evaluation and Assessment. Exercise on development of curriculum for Distance Education exclusively for farming community.

Suggested Readings

- Holmberg B. 1995. Theory and Practice of Distance Education. Routiedge Publ..
- Lakshmi Reddy MV. 2001. Towards Better Practices in Distance Education. Kanishka Publ.
- More MG. 2003. Hand Book of Distance Education.Lawrence Erlbaum Associates Publ.
- Panda.S. 2003. Planning & Management in Distance Education. Kogan Page Publ.
- Pathak CK. 2003. Distance Education: Prospects and Constraints. Rajat Publ.
- Sharma DC. 2005. Management of Distance Education. Anmol Publ.
- Sharma M. 2006. *Distance Education: Concepts and Principles*. Kanishka Publ.

AG.EXTN 512 : MARKET LED EXTENSION MANAGEMENT 1+1

Objective

The student will learn the significance of post harvest management& value addition in present market environment and the challenges and future strategy for market led extension management. Also identifies the information sources and develop strategy for market intelligence and the marketing infrastructure, multilevel marketing and linkages for market led extension. In addition the students would be learning the public private partnerships for market led extension management, the features of contract farming, WTO its implications on agriculture and Understanding the role of IT for market intelligence.

Theory

UNIT I

Agricultural extension at cross roads; Changing scenario of agricultural extension at the national level; Market led extension – emerging perspectives; Market led extension – issues and challenges; Dimensions of market led extension.

UNIT II

Agricultural marketing an overview; Development of a marketing plan, pricing concepts and pricing strategy; Consumer behaviour; Marketing communication and promotional strategies; The marketing research process; Agricultural trade liberalization and its impact; International marketing opportunities; Implications of AOA, TRIPS and IPRs agreements on agriculture; Agreement on SPS and TBT - an over view; Commodity features marketing.

UNIT III

Public private linkages in market led extension; Role of SHG in market led extension; Contact farming – a viable approach to meet market challenges; IT enabled approaches for market led extension and communication;
Weather service and crop modeling – An effective tool in market led extension.

Practical

Identification and analysis of different marketing sources for agricultural commodities. Development of strategy for an effective market intelligence system; Development of suitable marketing plan to suite rural situation; Visit to APEDA, Rythu Bazaars to study the processes and procedures related to market-led extension.

Suggested Readings

- Kaleel FMH & Krisnamurthy J. 2007. Market Led Extension Dimensions and Tools. Agro Tech Publ. Academy.
- Rajmanohar TP & Kumaravel KS. 2006. Contract Farming in India. ICFAI Univ. Press, Hyderabad.
- Subbalakshmi V. 2005. Globalization - Indian Experience. ICFAI Univ. Press, Hyderabad.
- Suresh K. 2005. *Rural Markets - Emerging Opportunities*. ICFAI Univ. Press, Hyderabad

AG.EXTN 601 : ADVANCES IN AGRICULTURAL EXTENSION 2+1

Objective

By the End of the course student will be able to

- Critically analyze different Agricultural Extension approaches
- Understand Agricultural Knowledge Information System (AKISs) ITK
- Understand Advances in Extension - Cyber extension, ICT enabled extension services; Market Led Extension, Public Private Partnership, Mainstreaming gender in extension organizational Innovations.
- Visualize implications of WTO - AOA and develop extension strategies.
- Understand extension reforms and Farmer Field Schools Decentralized Decision Making, bottom up planning, ATMA, FSBE & CIGs etc., ATIC, IVLP & Kisan Call Centres

Theory

UNIT I

Approaches of Agricultural Extension: A critical analysis of different approaches of agricultural extension. Importance and relevance of indigenous knowledge system, identification and documentation of ITK, Integration of ITK system in research formulation, Concept of Agricultural Knowledge and Information System, Training of Stakeholders of AKIS.

UNIT II

Cyber Extension - Concept of cyber extension, national and international cases of extension projects using ICT and their impact of agricultural extension, alternative methods of financing agricultural extension - Scope, limitations and experience and cases. Research - Extension -Farmer - Market linkage: Importance, Scope, Implications etc., Market - Led Extension, Farmer - Led Extension, Concept of Farm Field School, Farm School, Public - Private Partnership: Meaning, Models, Identification of various areas for partnership. Stakeholder's analysis in Extension. Main streaming gender in Extension - Issues and Prospects.

UNIT III

Implications of WTO - AOA for extension services, re-orientation of extension services for agri-business and marketing activities, GOI-NGO collaboration to improve efficiency of extension.

UNIT IV

Extension and contemporary issues: Extension and issues related to rural poverty. Privatization of Extension. Intellectual Property Rights (IPRs). Extension Reforms in India - Decentralized decision making, Bottom up planning, Farming System and Situation based Extension Delivery System, Extension delivery through Commodity Interest Groups. Organization innovations in Extension - ATIC, IVLP, Kisan Call Centres.

Practical

Analysis of ITK systems, cases on integration of ITK and formal research system, Analysis of cases on cyber extension and privatization of extension. Analysis of ATMA and SREP. Practicing bottom up planning. Visit to Public-Private -Farmer partnership. Learnings from Food and Nutritional Security and bio-diversity Projects and Programmes.

Suggested Readings

- Bagchi J. 2007. Agriculture and WTO Opportunity for India. Sanskruti.
- Chambers R, Pacy A & Thrupp LA. 1989. Farmers First. Intermediate Technology Publ.
- Crouch BR & Chamala S. 1981. Extension Education and Rural Development. Macmillan.
- John KC, Sharma DK, Rajan CS & Singh C. 1997. Farmers Participation in Agricultural Research and Extension Systems. MANAGE, Concept Publ. Co.
- Khan PM. 2002. Text Book of Extension Education. Himanshu Publ.
- Narasaiah ML. 2005. Agricultural Development and World Trade Organization. Discovery Publ.
- Talwar S. 2007. WTO Intellectual Property Rights. Serials Publ.
- Van den Ban BW & Hawkins BS. 1998. Agricultural Extension. S.K. Jain Publ.
- Venkaiah S. 2001. *New Dimensions of Extension Education*. Anmol Publ.

AG.EXTN 602 : ADVANCED DESIGNS AND TECHNIQUES IN SOCIAL SCIENCE RESEARCH **2+1**

Objective

By the End of the course student will be able to

• Develop & Standardize Attitude scale using different techniques of attitude scale construction.

• Develop skills of using Projected & Semi Projected & Semi Projected Techniques, Computer Package analysis and PRO Tools in Extension Research.

Theory

UNIT I

Scaling technique - meaning, types, principles, steps and quality, techniques of attitude scale construction - Paired comparison, Equal appearing intervals, Successive Intervals, Summated ratings, Scalogram analysis, Scale discrimination technique, Reliability and Validity of Scales. Sociometrics, content analysis, case studies, Q-sort techniques, Semantic different technique.

UNIT II

Projective and Semi projective techniques, Critical incident techniques, Computer packages for analysis - usage in Extension Research. Knowledge scale measurement. Participatory tools and techniques in behaviour Research - Data collection and Evaluation. Impact analysis, e-data collection and information analysis.

Practical

Practice in constructing a scale and use of scale in various situations. Reliability and validity of the scales developed, Application of Semi Projective and Projective techniques. Content analysis, case studies. Practicing participatory tools and techniques. Hands on experience on Computer Preparation and Data Collection instruments, review of previous studies.

Suggested Readings

- Burns RB. 2000. Introduction to Research Methods. Sage Publ. Chandrakandan K & Karthikeyan C. 2004. Behavioral Research Methodology. Classical Publ.

- Daivadeenam P. 2002. Research Methodology in Extension Education. Agro-Tech Publ. Academy.
- Kerlinger N Fred. 2002. Foundations of Behavioural Research. Surjeet Publ.
- Kothari CR. 2000. Research Methodology Methods & Techniques. 2nd Ed. Wishwa Prakasham.
- Ray GL & Mondal S. 1999. Research Methods in Social Science and Extension Education. Naya Prokash.
- Roger L & Domino WSK. 1980. Research Methods. Prentice Hall.
- Sadhu AM & Singh A. 2003 Research Methodology in Social Science. Himalaya Publ. House.
- Sarantakos S. 1998. Social Research. 2nd Ed. Macmillan.
- Sinha SC & Dhiman AK. 2002. Research Methodology. ESS Publ.
- Verma RK & Verma G. 2002. Research Methodology. Commonwealth Publ.
- Walizer MH & Panl L. 2002. Research Methods & Analysis; Searching for Relationships. Wiemil Harper & Row.
- Wilkinson TS & Bhandarkar PL. 2002. Methodology and Techniques of Social Research. Himalaya Publ. House.

AG.EXTN 603 : ADVANCES IN TRAINING TECHNOLOGY 2+1

Objective

By the end of the Course student will be able to
- Plan and design a training programme
- Plan & Develop effective training sessions
- Manage difficult situations while organizing training programmes
- Use different advanced participatory training methods

Theory

UNIT I

Paradigm shift in training - learning scenario, Training Approaches - Experiential learning - laboratory - organization development (system) approaches; Training Design, Designing an effective training programme, Harmonizing training needs, Course Objective, content and methods.

UNIT II

Designing an effective training session - the semantics involved, Designing experiential training sessions, simulation exercises, and openness in training transaction - managing dilemmas, ambivalence and conflicts and confusion (for both trainers and trainees).

UNIT III

Recent Training Techniques for understanding and facilitation team building, group dynamics, motivation and empowerment, laboratory methods: micro-lab process work, and sensitivity training, Psychological instruments as training tools: TAT, Inventories, Cases, etc.

UNIT IV

Participatory Training Techniques - Lecture, Brainstorming, Group discussion and Training Games. Role Play, Psycho-drama, Coaching, Counseling, etc., Trainer's roles and dilemmas, Factors Effecting Training Effectiveness and Training Evaluation.

Practical

Techniques of participatory training need assessment. Formulation of Course Objective, design of training programmes. Simulation exercises. Participatory training methods - Role Play & Brainstorming, Group discussion and Counseling and Conducting experiential learning sessions. Training evaluation - Techniques of Knowledge, Skill & Attitude evaluation. Visit to training institutions and study of training technologies followed.

Suggested Readings

- Agochiya D. 2002. Every Trainer's Handbook. Sage Publ.
- Alan B & Calardy 2004. Five Case Studies in Management Training. Jaico Publ.
- Kumar A. 2000. Management Training Process. Anmol Publ. Leslie Rae. 1998. Techniques of Training. Jaico Publ.
- Lynton RP & Pareek U. 1999. Training for Development. 2nd Ed. Vistar Publ.
- Reid MA. 1997. Training Interventions, Managing Employee Development. Jaico. Publ.
- Samanta RK. 1993. Training Methods for Management and Development. M.D. Publ.

❖ Sethy ED. 2003. *A Practical Hand Book on Training*. Anmol Publ.

AG.EXTN 604 : ORGANIZATIONAL DEVELOPMENT 2+1

Objective

By the end of the course student will be able to

• Understand & Study the Organization in terms of types, Characteristics, Needs, Motives, Organization behaviour, Organization Communication, Organization development and Individual behaviour in organization.

• To anlayse the factors effecting organizational effectiveness and distinguish between functional and non functional organization.

Theory

UNIT I

Introduction to organizations: Concept and Characteristics of organizations, Organizational Behvaiour - Context and concept - levels of organizations - formal and informal organizations, Theories of organizations: Nature of organizational theory - classical theories - features of Bureaucracy - administrative theory and Scientific management - Neo-classical theories - the human relations movement - modern theory.

UNIT II

Systems approach to study organization needs and motives - Attitude, values and ethical behaviour - alienation and work - work motivation - communication and interpersonal behaviour - organization communication

- leadership behaviour - decision making, problem solving techniques - organizational climate - change proneness and resistance to change, Organizational change, Organizational structure - Process in organizing - Dimension of Motivation Climate.

UNIT III

Departmentation - Span of Management - Delegation of authority - Centralization and decentralization - line and staff organization - functional organization - divisonalisation - Project organization - Matrix organization- free form organization - top management structure.

UNIT IV

Individual behaviour in organization. Fundamentals of Human relations and Organizational behaviour, Groups and teams - Organisational culture and performance. Dynamics of Organization behaviour - leadership conflict situations and inter group behavior- Organisational Development - Factors effecting organization effectiveness. Creativity, leadership, motivation and organization development.

Practical

Analysis of organization in terms of process - attitudes and values, motivation, leadership. Simulation exercises on problem-solving - Study of organizational climate in different organizations. Study of organizational structure of development departments, Study of departmentalization, span of control delegation of authority, decisions making patterns, Study of individual and group behaviour at work in an organization. Conflicts and their management in an organization. Comparative study of functional and non-functional organsiations and drawing factors for organizational effectiveness.

Suggested Readings

❖ Ancona, Kochaw, Scully, Van Maanen, Westney 1999. Organizational Behaviour and Processes. South Western College Publ., New York.
❖ Banerjee M. 1984. Organizational Behaviour. Allied Publ.
❖ Deka GC. 1999. Organizational Behaviour - A Conceptual Applicational Approach. Kanishka Publ.
❖ Dwivedi RS. 2006. Human Relations and Organization Behaviour- A Global Perspective. 5th Ed. Macmillan.
❖ Kumar A. 2000. Organizational Behaviour Theory and Practice. Anmol Publ.
❖ Luthans F. 1998. Organizational Behavior. Tata McGraw Hill.
❖ Luthans F. 2001. Organizational Behaviour. McGraw Hill.
❖ Newstrom JW & Davis K. 1997. Human Behaviour at Work. Tata McGraw Hill.
❖ Robbins SP. 2007. Organizational Behaviour. Prentice Hall.

- Shaun T & Jackson T. 2003. The Essence of Organizational Behaviour. Practice Hall of India.
- Stephen RR. 1999. *Organizational Behaviour*. 5th Ed. Practice Hall of India.

AG.EXTN 605 : ADVANCED INSTRUCTIONAL TECHNOLOGY 2+1

Objective

By the end of the course student will be able to
• Understand Agricultural Education Scenario in the country and
Curriculum development process
• Plan & Prepare and present course outline, Lesson Plan & Skill plan
• Develop appropriate Teaching & Learning Styles
• Use innovative instructional aids & methods

Theory

UNIT I

Concepts in Instructional Technology, Scope of Instructional Technology. History of agricultural education in India. Guidelines for curriculum development in Agricultural Universities. Curriculum design development.

UNIT II

Course outline, Lesson plans for theory and practicals. Teaching and learning styles. Theories of learning. Cognitive levels. Instructional Course Objective. Motivation of students.

UNIT III

Instructional Methods. Experiential learning cycle. Innovative Instructional Aids. Computer Assisted Instruction. Programmed instruction technique. Team Teaching. E-Learning, Art of Effective Communication. Distance education. Student evaluation - Question Bank. Appraisal of Teacher Performance. Review of research in Instructional Technology.

Practical

Formulation of instructional Course Objective. Development and presentation of course outlines. Preparation & presentation of lesson plans for theory & practical with CAI design. Preparation of innovative low cost instructional aids. Development of model question bank. Preparation of schedule for teacher evaluation. Visit to Distance Education centre. Study of research reviews and Presentation of reports.

Suggested Readings

- Agarwal JC. 2007. Essentials of Educational Technology Innovations in Teaching – Learning. 2nd Ed. Vikas Publ. House.
- Agarwal R. 2000. Educational Technology and Conceptual understanding. Anmol Publ.
- Dayal BK. 2005. Educational Planning and Development. Dominant Publ.
- Grover I, Kaushik S, Yadav L & Varma SK. 2002. Communication and Instructional Technology. Agro Tech Publ. Academy.
- Jacobsen D, Eggen P & Kauchak D. 1985. Methods for Teaching - A Skills Appraoch. 2nd Ed. Charles E. Merrill Publ.
- Joyee B & Well M. 1980. Models of Teaching. 2nd Ed. Prentice Hall.
- Khan PM. 2002. Text Book of Extension Education. Himanshu Publ.
- Rush N. 1987. Technology Based Learning - Selected Readings. London Publ. Co., New York.
- Tara Chand 1999. Educational *Technology*. Anmol Publ.

AG.EXTN 606 : THEORY CONSTRUCTIONS IN SOCIAL SCIENCES 2+0

Objective

By the end of the course student will be able to develop skills of theory building and scientific application of theoretical concept in Social Sciences by applying appropriate statistical tests.

Theory

UNIT I

Importance of theory constructions in social science. Theory: Meaning, elements, Ideal Criteria, Functions, Types. Definitions: Meaning, types and Rules.Generalizations: Meaning, Classification. Relationship: Meaning Types.

UNIT II

Terminologies used in theory constructions: Axiom, Postulate, Proposition, Theorem, Fact, Concept, Construct, Probability and Measurement Basic Derived. Steps in theory building - Axiomatic Techniques, Historical approaches. Scientific application Theoretical concept in Social Sciences. Test of Theory: Applying appropriate statistical tests.

Suggested Readings

- Blalock HM. Theory Construction: Form verbal to Mathematical Formulations. Prentice Hall.
- Dubin R. Theory Building. The Free Press, New York.
- Gibbs JP. Sociological Theory Construction. The Dryden Press, Illionis.
- Hage J. Techniques and Problems of Theory Constructions in Sociology. John Wiley & Sons
- Stinchombe AL. Construction of Sociological Theories. Harcourt, Brace & World. Wionton CA. Theory and *Measurement in Sociology*. John Wiley & Sons.

AG.EXTN 607 : ADVANCED MANAGEMENT TECHNIQUES 2+1

Objective

By the end of the course student will be able to

• Develop understanding on concept of MIS, its scope in Agriculture Extension Organization.

• Understand, Develop and Evaluate the MBO System

• To cope up with stress, Resolve conflicts and develop effective inter personal communication skills using Transactional analysis.

• To plan & use, DSS, AI, ES, PERT, CPM

Theory

UNIT I

Management Information System (MIS): Basic concepts, types of information needed at various levels, design of MIS in an agricultural extension organization. Scope for computerization, system alternatives and Evaluation. Implementation, operation and maintenance of the system.

UNIT II

Management by Course Objective (MBO): Elements of the MBO system. The Process of MBO. Making MBO effective. Evaluation of the MBO system - strengths and weaknesses. Transactional Analysis (TA): Ego states, transactions, inter relationships, strokes, stamps.

UNIT III

Managing Organizational Stress: Sources of stress in organization, effect of stress. Coping mechanisms and managing stress, Stress management, Team Building Process: Types of teams. Steps in teamwork, Facilitators and barriers to effective relationships, nature of prejudice, tips in reducing interpersonal conflicts, inter-group conflict, resolving techniques. Confect management, tips in reducing interpersonal conflicts.

UNIT IV

Decision Support Systems (DSSs): Basic information about Artificial Intelligence (AI) Expert System (ESs), their future applications in extension system. Forecasting techniques - time series analysis and Delphi, decision making and talent management PERT, CPM Techniques and time management.

Practical

Managements Information system, in research & development organizations. Study of Management by Course Objective in an organization. Transactional Analysis, exercises on Team building process, coping skills with organizational stress, exercises on Decision Support Systems (DSSs). Practicals exercise on forecasting techniques, Visit to Management organizations.

Suggested Readings

- Chaudhary AK. 1999. Encyclopedia of Management Information System. Vols. I, II. Anmol Publ.
- Hari Gopal K. 1995. Conflict Management - Managing Interpersonal Conflict. Oxford & IBH.
- James O'Brien 1999. Management Information System. Tata McGraw-Hill.

- Koontz H & Welhrich H. 2004. Essentials of Management. 5th Ed. Tata. McGraw- Hill.
- Lauden & Lauden 2003. Management Information System. Pearson Edu.
- Maheswari BL. 1980. Organizational Decision Styles & Orgul Effectiveness. Vikas Publ.
- McGrath SJEH. 2007. Basic Management Skills for All. 7th Ed. Prentice Hall of India.
- West JD & Leevy FK. 1998. A Management Guide to PERT / CPM with GERT / PDM / DCPM *and Other Networks*. Prentice Hall of India.

AG.EXTN 608 : MEDIA MANAGEMENT 2+1

Objective

• To familiarize the students with the working of print, electronic, New Media & Traditional folk media.
• To develop working skills needed for Print, Radio and T.V. Journalism to reach farming community.
• To develop in students an understanding on Mass Communication Process and Media Management its impact on the society.
• To develop writing skills for different media.

Theory

UNIT I

Media Management – Introduction, Definition, Principles and Significance of Management. Media Ownership patterns in India – Proprietorship, Partnership, private Ltd, Public companies, Trusts, Co-operatives, Religious Institutions (Societies) & Franchisees (Chains). Marketing Function – Product, Price, and Placement & Promotions.

UNIT II

Mass Communication – Meaning, Concept, Definition and Theories of Mass Communication. The Mass Media – History, functions, uses and Theories of Media. Journalism – Meaning, definition, Scope, functions and different types of Journalism. Journalism as communication tool. Farm Journalism – meaning and Developments in Farm Journalism in India. Different problems with Farm Journalism. Print Media – History, the role of the press, news, Types of News, electronics of News and Sources of News, the making of newspaper & magazines, press codes and ethics, Media Laws. News story – Principles of writing, structure a news story, procedure in writing the news story and the elements of style. Success stories & feature articles – writing for success & feature articles, Types of Feature articles. Information materials – Types of information materials and user. Techniques in book Publishing. Editing – Principles, Tools & Techniques and art of Proof Reading – Techniques, Measuring Readability of writing.

UNIT III

Electronic Media-Role and Importance of Radio -History, Radio Role in TOT, writing and presentation techniques, Different Programmes of Farm Broadcast, developing content for farm broadcast, Role of FM Radio in Agriculture, Ethics of Broad casting, Broadcasting Policy and code. Community Radio – Concept, meaning, role in TOT, Cases of Community radio. Television – History - Role in TOT , Fundamentals of Television Production, Techniques of Script writing for TV, Visual Thinking, language & Style, Farm Telecast programmes, cable and satellite TV and their impact, Ethics of Telecasting, policy and code. Video Production Technology – Potential and its utilization, Typology of farm Video production, Types of Video Production and equipment used in the production, Procedure or Technique of video production. Cassette Technology – Role in TOT, Techniques of production of cassettes for the farming community. Traditional Media – Role of Folk Media in TOT and integration with electronic media.

UNIT IV

Advances in communication Technology – Management of Agricultural Information System (MAIS). Use of computers in Agriculture – Application of IT in Agriculture. Use of Modern Communication Medium- Electronic Video, Teletext, tele conference, Computer assisted instruction, Video conferencing, - Features, Advantages, Limitations and risk factory involved in New Media. Designing and developing of communication and media strategy for developmental programmes. Online journalism scope & importance.

Practical

Exercise on Writing for Print Media – Writing News / Success Stories / Feature articles for

different topics related to Agriculture & allied fields. Exercise of editing & proof reading the Farm News for News papers – different types of intro and leads. Exercise of Writing for Radio, TV, Preparation of story board for farm Video Production – Script writing for Radio and T.V. Visit to media management organizations for studying the principles, procedures and processes in managing the media. Participation and Interaction through video conference. Developing communication & Media Strategy for selected developmental programme / activity.

Suggested Readings

- Bhaskaran C, Prakash R & Kishore Kumar N. 2008. Farm Journalism in Media Management. Agro-Tech Publ. Academy.
- Chattergee PC. 1991. Broadcasting in India. Sage Publ.
- Chiranjeev A. 1999. Electronic Media Management. Authors Press.
- D'Souza YK.1998. Principles and Ethics of Journalism and Mass Communication. Commonwealth Publ.
- Defleur ML & Dennis EE. 2001. Understanding Mass Communications. Goyalsaab Publ.
- Jain SC. 2006. International Marketing Management. CBS Publ.
- Keval J Kumar. 2004. Mass Communication in India. Jaico Publ.
- Malhan PN. 2004. Communication Media: Yesterday, Today and Tommorow. Directorate of Publication Division, New Delhi.
- Mehta DS. 1992. Mass Communication and Journalism in India. Allied Publ.
- Panigrahy D. 1993. Media Management in India. P. K. Biswasroy (Ed.). Kanishka Publ.
- Shrivastava KM. 1995. News Writing for Radio and TV. Sterling Publ.
- Sinha KK. 2001. *Business Communications*. Galgotia Publ.

AG.EXTN 609 : TRANSFER OF TECHNOLOGY IN AGRICULTURE 2+1

Objective

By the end of the Course student will be able to

• Develop thorough understanding on different systems of Technology Transfer

• Develop appropriate communication & Media Strategy suitable to the System of Technology Transfer

• Analyse the constraints in Systems of Technology Transfer Technology and Suggest suitable Strategies.

Theory

UNIT I

Technology - Meaning and Concepts - Appropriate technology, transfer of technology - meaning and concepts. Systems of transfer of technology - Knowledge Generating System (KGS) - Knowledge Disseminating System (KDS) - Knowledge Consuming System (KCS) - Input Supplying Agencies System (ISAS).

UNIT II

Appropriateness of communication media in the system of technology transfer. New communication strategy for transfer and adoption of Agricultural technology. Extension training in transfer of technology.

UNIT III

Analysis. Constraints in Transfer of Technology, agencies or departments involved in TOT. Extension professional in TOT. Attributes of Technology and its Relation in TOT process. TOT to resource poor farmers. Role of Key communicators or local leaders in TOT. Private and Public partnership in TOT.

Practical

Analysis of Transferred technology. Analysis of knowledge generation and consuming systems. Formulation of communication strategies, Study of attributes of selected fast spreading technologies and slow technologies, study of constraints in TOT, visit to TOT centres of ICAR and SAU, Identification of key communicators, Case studies of Public-Private Partnerships, Visits to the print and electronic media centres to study their role in TOT.

Suggested Readings

- Chaturvedi TN. 1982. Transfer of Technology among Developing Countries; Need for Strengthening Cooperation. Gitanjali Publ. House.
- Dunn DD. 1978. Appropriate Technology With a Human Face. Macmillan Press.
- Kapoor SK, Roy PB & Roy AK. 1980. Role of Information Centres in Technology Transfer. IASLIC, Kolakata.
- Lekhi RK. 1984. Technological Revolution in Agriculture. Classical Publ. Co.
- Singh SN. 1991. Transfer of Technology to Small Farmers; An Analysis of Constraints and Experience. Concept Publ. Co.
- Wallender HW. 1980. Technology Transfer of Management in the Developing Countries. Ballinger Publ. Co., Cambridge.

AGRICULTURAL STATASTICS/STATIS

AG. STAT. 501 : MATHEMATICAL METHODS FOR APPLIED SCIENCES 2+0

Objective

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. The students would get an exposure to differentiation, integration and differential equation.

Theory

UNIT I

Variables and functions; limit and continuity. Specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, function of a function, derivative of higher order, partial derivatives. Application of derivatives in agricultural research; determination of points of inflexion, maxima and minima in optimization, etc.

UNIT II

Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral; Applications of integration in agricultural research with special reference to economics and genetics, engineering, etc.

UNIT III

Vectors and vector spaces, Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; Eigen values and eigen vectors. Determinants - evaluation and properties of determinants, application of determinants and matrices in solution of equation for economic analysis.

UNIT IV

Set theory-set operations, finite and infinite sets, operations of set, function defined in terms of sets.

Suggested Readings

- Harville DA. 1997. Matrix Algebra from a Statistician's Perspective. Springer.
- Hohn FE. 1973. Elementary Matrix Algebra. Macmillan.
- Searle SR. 1982. Matrix Algebra Useful for Statistics. John Wiley.
- Stewart J. 2007. Calculus. Thompson.
- Thomas GB. Jr. & Finney RL. 1996. *Calculus.* 9 Ed. Pearson Edu. th

AG. STAT. 511 : STATISTICAL METHODS FOR APPLIED SCIENCES 3+1

Objective

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions,

parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

UNIT I

Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability. Random variable and mathematical expectation.

UNIT II

Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, *t* and *F* distributions. Tests of significance based on Normal, chi-square, *t* and *F* distributions. Large sample theory.

UNIT III

Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Polynomial regression models and their fitting. Probit regression analysis by least squares and maximum likelihood methods, confidence interval for sensitivity; Testing for heterogeneity.

UNIT IV

Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

UNIT V

Introduction to multivariate analytical tools- Hotelling's T^2 Tests of hypothesis about the mean vector of a multinormal population. Classificatory problems and discriminant function, D2-statistic and its applications; Cluster analysis, principal component analysis, canonical correlations and Factor analysis.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F; Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution; Correlation and regression analysis, fitting of orthogonal polynomial regression; applications of dimensionality reduction and discriminant function analysis; Non-parametric tests.

Suggested Readings

- Anderson TW. 1958. An Introduction to Multivariate Statistical Analysis. John Wiley.
- Dillon WR & Goldstein M.1984. Multivariate Analysis - Methods and Applications. John Wiley.
- Goon AM, Gupta MK & Dasgupta B.1977. An Outline of Statistical Theory. Vol. I. The World Press.
- Goon AM, Gupta MK & Dasgupta B.1983. Fundamentals of Statistics.Vol.I.The World Press.
- Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley.
- Hogg RV & Craig TT. 1978. Introduction to Mathematical Statistics. Macmillan.
- Morrison DF. 1976. Multivariate Statistical Methods. McGraw Hill.
- Siegel S, Johan N & Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley.
- Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
- Electronic Statistics Text Book: http://www.statsoft.com/textbook/stathome.html.

AG. STAT. 512 : EXPERIMENTAL DESIGNS 2+1

Objective

This course is meant for students of agricultural and animal sciences other than Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of

experimental data.

Theory

UNIT I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

UNIT II

Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV

Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ Lattice design, alpha design - concepts, randomisation procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

UNIT V

Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation.

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Analysis of resolvable designs; Fitting of response surfaces.

Suggested Readings

- Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
- Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.
- Federer WT. 1985. Experimental Designs. Mac Millan.
- Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
- Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.
- Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley.
- Design Resources Server: www.iasri.res.in/design.

AG. STAT. 521 : APPLIED REGRESSION ANALYSIS 2+1

Objective

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multicollinearity and Heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

Theory

UNIT I

Introduction to correlation analysis and its measures; Correlation from grouped data, Biserial correlation, Rank correlation; Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

UNIT II

Problem of correlated errors; Auto correlation; Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multicollinearity; Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

UNIT III

Examining the multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation; regression approach applied to analysis of variance in one way classification.

UNIT IV

Heteroscedastic models, Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

Practical

Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection; Handling of correlated errors, multicollinearity; Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

Suggested Readings

- Draper NR & Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.
- Ezekiel M. 1963. Methods of Correlation and Regression Analysis. John Wiley.
- Kleinbaum DG, Kupper LL, Muller KE & Nizam A. 1998. Applied Regression Analysis and Multivariable Methods. Duxbury Press.
- Koutsoyiannis A. 1978. Theory of Econometrics. MacMillan.
- Kutner MH, Nachtsheim CJ & Neter J. 2004. Applied Linear Regression Models. 4th Ed. With Student CD. McGraw Hill.

AG. STAT. 531 : DATA ANALYSIS USING STATISTICAL PACKAGES 2+1

Objective

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students an hands on experience in the analysis of their research data. This course is useful to all disciplines.

Theory

UNIT I

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II

Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, *t* and *F* statistics.

UNIT III

Concept of analysis of variance and covariance of data for single factor, multi-factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

UNIT IV

Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.

UNIT V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data; Spatial analysis; Neural networks.

Practical

Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data. Robust Estimation, Testing linearity and normality assumption, Estimation of trimmed means etc., Cross tabulation of data including its statistics, cell display and table format and means for different sub-classifications; Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample *t* -test, two sample *t* -test, paired *t* -test, test for large samples - Chi-squares test, F test, One way analysis of variance, contrast and its testing, pairwise comparisons; Multiway classified analysis of variance - cross-classification, nested classification, factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components; Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts,

Estimation of variance components in unbalanced data sets - maximum likelihood, ANOVA, REML, MINQUE; Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models - curve estimation models, examination of residuals; Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis - obtaining principal component, spectral composition; Analysis of time series data - fitting of ARIMA models, working out moving averages. Spatial analysis; Neural networks.

Suggested Readings

- Anderson CW & Loynes RM. 1987. The Teaching of Practical Statistics. John Wiley.
- Atkinson AC. 1985. Plots Transformations and Regression. Oxford University Press.
- Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmount, California.
- Chatfield C & Collins AJ. 1980. Introduction to Multivariate Analysis. Chapman & Hall.
- Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall.
- Chatfield C. 1995. Problem Solving: A Statistician's Guide. Chapman & Hall.
- Cleveland WS. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.
- Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
- Erickson BH & Nosanchuk TA. 1992. Understanding Data. 2nd Ed. Open University Press, Milton Keynes.
- Snell EJ & Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman & Hall.
- Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.
- Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, Conn.
- Velleman PF & Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.
- Weisberg S. 1985. Applied Linear Regression. John Wiley.
- Wetherill GB. 1982. Elementary Statistical Methods. Chapman & Hall.
- Wetherill GB.1986. Regression Analysis with Applications. Chapman & Hall.
- Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
- Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
- Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
- Course on Experimental design: http://www.stat.sc.edu/~grego/courses/stat706/.
- Design Resources Server: www.iasri.res.in/design.
- Analysis of Data: Design Resources Server.
- http://www.iasri.res.in/design/Analysis%20of%20data/Analysis%20of%2 Data.html.

AG. STAT. 533 : STATISTICAL METHODS FOR CROP PROTECTION- I 2+1

Review of test of significance–t, Z and F test. Review of sampling. Principles of experimental design - replication, randomization and local control, Analysis of variance I : One way classification, Completely randomized design, lsd and DNMRT test. Analysis of variance II : Multi way classification - Randomized Complete Block Design, Control vs Rest analysis, Latin Square Design, missing values, Transformations. Pooled analysis - over space and time, Introduction to simple and multiple correlation and regression. Introduction to Bioassay – LD 50, LD 90, ED 50 and ED 90, probit analysis.

AG. STAT. 534 : STATISTICAL METHODS FOR CROP PROTECTION- II 2+1

Review of linear correlation and regression, Fitting of linear and exponential regression equation, Multiple regression and correlation, non linear regression, Direct assay investigation of dose response relationship, parallel line assay, slope ratio assay, choice of doses and efficiency in direct assay designs suitable for bio-assay. Indirect assay based on quantal response, probit, logit and angular transformations and percentage response. bacteriological sampling in dilution series, other methods of estimation of median effective dose.

AG. STAT. 535 : STATISTICAL METHODS FOR CROP PRODUCTION- I 2+1

Principles of experimental design - replication, randomization and local control, plot size and shape, border effects, shape and size of plots and blocks, estimation of size of experiments for

specified accuracy. Analysis of variance I: One way classification, Completely randomized design, lsd and DNMRT test. Analysis of variance II Multi way classification - randomized complete block design, Control vs Rest analysis, Latin square design, efficiency, missing values, Transformations. Concept of factorial experiment, Split plot design - over space and time, efficiency, missing values. Strip plot design. Experiments on perennial crops. Planning of experiments on cultivators' fields. Choice of treatments.

AG. STAT. 536 : STATISTICAL METHODS FOR CROP PRODUCTION- II 2+1

Analysis of Factorial experiments 2^2, 3^2, 3^3 - single degree of freedom comparison. Response curve. Confounding in 2^n, 3^2, and 3^3 experiments - complete and partial confounding. Pooled analysis, Long term experiments, direct, residual and cumulative effects. Covariance analysis for simple and factorial experiments. Multiple regression and correlation, non linear regression, Covariance analysis for simple and factorial experiments. the method of fitting constant,

AG. STAT. 537 : STATISTICAL METHODS FOR SOCIAL SCIENCES- I 2+1

Scope of statistics for social science research, frequency distribution and statistical measures. Concept of sampling, simple random sampling, choice of strata, stratified random sampling, sampling with probability proportional to size, sampling and non-sampling errors. Parametric test, t, Z and F. Non-parametric test Sign-test, Wilcoxon matched pairs, Signed rank test, Mann-Whitney U test, Wald-Wolfowitz run test, Median test. Correlation, Rank correlation, Regression analysis, Introduction to Factor analysis and Path analysis. Chi-square test for homogeneity, independence and goodness of fit. Analysis of time series data. Index numbers, moving averages.

AG. STAT. 538 : STATISTICAL METHODS FOR SOCIAL SCIENCES -II 2+1

Multiple regression and correlation, non linear regression, Regression diagnostics. Selection of variables. Adequacy of models. Application of multivariate analysis. Probability sampling, Sampling distribution, Simple random sampling. Estimation of proportions, confidence interval, determination of sample size, inverse sampling. Sampling with varying probabilities with replacement. Stratified sampling. Ratio and regression methods of estimation. Cluster sampling. Multi - stage sampling. Self weighting designs. Systematic sampling.

AG. STAT. 539 : STATISTICAL METHODS FOR CROP IMPROVEMENT 2+1

Principles of experimental design - replication, randomization and local control, One way and two way classification - CRD, RBD and LSD, missing values, Transformations, Control vs Rest analysis. Covariance analysis for simple and factorial experiments. Statistical models, expected mean squares, test of significance. Progeny row trial, Compact family block designs. Introduction to incomplete block design, Analysis of Balanced block designs with and without recovery of inter block information. Partially balanced incomplete block designs. Lattice design. Augmented design, Introduction to path analysis.

AG. STAT. 540 : STATISTICAL GENETICS-II 2+1

Genetic drift, Genetic load. Effect of finite population size. Effect of linkage, epitasis and inbreeding on quantitative characters. Multiple alelism in continuous variation. Maternal effects. Genotype x environment interaction—its role in analysis of yield stability, estimation of various stability measures. Out breeding and crossbreeding in plant and animal experiments. Various mating designs NCD I, II, III including their genetic analysis. Concepts of general and specific combining ability. Diallel, partial diallel and triallel cross. Basis of selection. Response to selection. Combined selection. Selection for several traits. Selection indices. Restricted selection indices. Phenotypic index. Response to selection. Correlated response to selection. Progeny testing and sire evaluation.

Practical

Effect of linkage, epistasis and inbreeding on mean and variance of metric traits. Stability parameters. Mating designs - NCD I, II, III - complete and partial diallel cross experiments, triallel cross experiments. Selection index including phenotypic index, restricted selection index, correlated response to selection, progeny testing and estimation of sire-index.

AG. STAT. 541 : STATISTICAL METHODS FOR ANIMAL SCIENCES 2+1

Sources of magnitude of errors in experiments with animals, experimental designs and methods of analysis adopted to specific types of animal research - Completely randomized designs, Randomized block design, Latin square design, Factorial experiments and switch over trials, relative efficiency of alternate design. Amount of data required for specified accuracy. Multivariate analysis with special reference to animal science research, LSD and DNMRT tests.

AG. STAT. 542 : AGRICULTURAL STATISTICS 2+1

Statistics - meaning, definition, aims and importance in agriculture, Overview of measures of central tendency and measure of dispersion, sampling. Test of significance – t, Z, Chi square and F test, Correlation and Regression Analysis, Analysis of variance, Completely Randomized Design (CRD), Randomized Block Design (RBD), Control vs Rest analysis and Factorial experiments in CRD and RBD, Comparison of means lsd.

AG. STAT. 551 : MATHEMATICAL METHODS – I 3+0

Objective

This course lays the foundation of all other courses of Statistics / Agricultural Statistics discipline by preparing them to understand the importance of mathematical methods in research. The students would be exposed to the basic mathematical tools of real analysis, calculus, differential equations and numerical analysis. This would prepare them to study their main courses that involve knowledge of Mathematics.

Theory

UNIT I

Real Analysis: Convergence and divergence of infinite series, use of comparison tests - D'Alembert's Ratio - test, Cauchy's nth root test, Raabe's test, Kummer's test, Gauss test. Absolute and conditional convergence. Riemann integration, concept of Lebesgue integration, power series, Fourier, Laplace and Laplace -Steiltjes' transformation, multiple integrals.

UNIT II

Calculus: Limit and continuity, differentiation of functions, successive differentiation, partial differentiation, mean value theorems, Taylor and Maclaurin's series. Application of derivatives, L'hospital's rule. Integration of rational, irrational and trigonometric functions. Application of integration.

UNIT III

Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient.

UNIT IV

Numerical Analysis: Simple interpolation, Divided differences, Numerical differentiation and integration.

Suggested Readings

- Bartle RG. 1976. Elements of Real Analysis. John Wiley.
- Chatterjee SK. 1970. Mathematical Analysis. Oxford & IBH.
- Gibson GA. 1954. Advanced Calculus. Macmillan.
- Henrice P. 1964. Elements of Numerical Analysis. John Wiley.
- Hildebrand FB. 1956. Introduction to Numerical Analysis. Tata McGraw Hill.
- Priestley HA. 1985. Complex Analysis. Clarenton Press.
- Rudin W. 1985. Principles of Mathematical Analysis. McGraw Hill.
- Sauer T. 2006. Numerical Analysis With CD-Rom. Addison Wesley.
- Scarborough JB. 1976. Numerical Mathematical Analysis. Oxford & IBH.
- Stewart J. 2007. Calculus. Thompson.
- Thomas GB Jr. & Finney RL. 1996. Calculus. 9 Ed. Pearson Edu. th

AG. STAT. 552 : MATHEMATICAL METHODS – II 2+0

Objective

This is another course that supports all other courses in Statistics / Agricultural Statistics. The students would be exposed to the advances in Linear Algebra and Matrix theory. This would prepare them to study their main courses that involve knowledge of Linear Algebra and Matrix

Algebra.

Theory

UNIT I

Linear Algebra: Group, ring, field and vector spaces, Sub-spaces, basis, Gram Schmidt's orthogonalization, Galois field - Fermat's theorem and primitive elements. Linear transformations. Graph theory: Concepts and applications

UNIT II

Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form. Determinants, rank and inverse of matrices. Special matrices – idempotent, symmetric, orthogonal. Eigen values and eigen vectors. Spectral decomposition of matrices

UNIT III

Unitary, Similar, Hadamard, Circulant, Helmert's matrices. Kronecker and Hadamard product of matrices, Kronecker sum of matrices. Sub-matrices and partitioned matrices, Permutation matrices, full rank factorization, Grammian root of a symmetric matrix. Solutions of linear equations, Equations having many solutions.

UNIT IV

Generalized inverses, Moore-Penrose inverse, Applications of g-inverse. Spectral decomposition of matrices, Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of matrices, Quadratic forms.

Suggested Readings

- Aschbacher M. 2000. Finite Group Theory. Cambridge University Press.
- Deo N. 1984. Graph Theory with Application to Engineering and Computer Science. Prentice Hall of India.
- Gentle JE. 2007. Matrix Algebra: Theory, Computations and Applications in Statistics. Springer.
- Graybill FE.1961. Introduction to Matrices with Applications in Statistics.Wadsworth Publ.
- Hadley G. 1969. Linear Algebra. Addison Wesley.
- Harville DA. 1997. Matrix Algebra from a Statistician's Perspective. Springer.
- Rao CR. 1965. Linear Statistical Inference and its Applications. 2nd Ed.John Wiley.
- Robinson DJS. 1991. A Course in Linear Algebra with Applications. World Scientific.
- Searle SR. 1982. Matrix Algebra Useful for Statistics. John Wiley.
- Seber GAF. 2008. *A Matrix Handbook for Statisticians*. John Wiley.

AG. STAT. 560 : PROBABILITY THEORY 2+0

Objective

This is a fundamental course in Statistics. This course lays the foundation of probability theory, random variable, probability distribution, mathematical expectation, etc. which forms the basis of basic statistics. The students are also exposed to law of large numbers and central limit theorem. The students also get introduced to stochastic processes.

Theory

UNIT I

Basic concepts of probability. Elements of measure theory: class of sets, field, sigma field, minimal sigma field, Borel sigma field in R, measure, probability measure. Axiomatic approach to probability. Properties of probability based on axiomatic definition. Addition and multiplication theorems. Conditional probability and independence of events. Bayes theorem.

UNIT II

Random variables: definition of random variable, discrete and continuous, functions of random variables. Probability mass function and Probability density function, Distribution function and its properties. Notion of bivariate random variables, bivariate distribution function and its properties. Joint, marginal and conditional distributions. Independence of random variables. Transformation of random variables (two dimensional case only).

Mathematical expectation: Mathematical expectation of functions of a random variable. Raw and central moments and their relation, covariance, skewness and kurtosis. Addition and multiplication theorems of expectation. Definition of moment generating function, cumulating generating function, probability generating function and statements of their properties.

UNIT III

Conditional expectation and conditional variance. Characteristic function and its properties. Inversion and uniqueness theorems. Functions, which cannot be characteristic functions. Chebyshev, Markov, Cauchy-Schwartz, Jenson, Liapounov, holder's and Minkowsky's inequalities. Sequence of random variables and modes of convergence (convergence in distribution, in probability, almost surely, and quadratic mean) and their interrelations. Statement of Slutsky's theorem. Borel –Cantelli lemma and Borel 0-1 law.

UNIT IV

Laws of large numbers: WLLN, Bernoulli and Kintchin's WLLN. Kolmogorov inequality, Kolmogorov's SLLNs. Central Limit theorems: Demoviere- Laplace CLT, Lindberg – Levy CLT, Liapounov CLT, Statement of Lindeberg-Feller CLT and simple applications. Definition of quantiles and statement of asymptotic distribution of sample quantiles.

UNIT V

Classification of Stochastic Processes, Examples. Markov Chain and classification of states of Markov Chain.

Suggested Readings

- Ash RB. 2000. Probability and Measure Theory. 2nd Ed. Academic Press.
- Billingsley P. 1986. Probability and Measure. 2nd Ed. John Wiley.
- Capinski M & Zastawniah. 2001. Probability Through Problems. Springer.
- Dudewicz EJ & Mishra SN. 1988. Modern Mathematical Statistics. John Wiley.
- Feller W. 1972. An Introduction to Probability Theory and its Applications. Vols. I., II. John Wiley.
- Loeve M. 1978. Probability Theory. 4th Ed. Springer.
- Marek F. 1963. Probability Theory and Mathematical Statistics. John Wiley.
- Rohatgi VK & Saleh AK Md. E. 2005. An Introduction to Probability and Statistics. 2nd Ed. John Wiley.

AG. STAT. 561 : STATISTICAL METHODS 2+1

Objective

This course lays the foundation of probability distributions and sampling distributions and their application which forms the basis of Statistical Inference. Together with probability theory, this course is fundamental to the discipline of Statistics. The students are also exposed to correlation and regression, and order statistics and their distributions. Categorical data analysis is also covered in this course.

Theory

UNIT I

Descriptive statistics: probability distributions: Discrete probability distributions ~ Bernoulli, Binomial, Poisson, Negative-binomial, Geometric and Hyper Geometric, uniform, multinomial ~ Properties of these distributions and real life examples. Continuous probability distributions ~ rectangular, exponential, Cauchy, normal, gamma, beta of two kinds, Weibull, lognormal, logistic, Pareto. Properties of these distributions. Probability distributions of functions of random variables.

UNIT II

Concepts of compound, truncated and mixture distributions (definitions and examples). Pearsonian curves and its various types. Sampling distributions of sample mean and sample variance from Normal population, central and non–central chi-Square, *t* and *F* distributions, their properties and inter relationships.

UNIT III

Concepts of random vectors, moments and their distributions. Bivariate Normal distribution - marginal and conditional distributions. Distribution of quadratic forms. Cochran theorem. Correlation, rank correlation, correlation ratio and intra-class correlation. Regression analysis, partial and multiple correlation and regression.

UNIT IV

Sampling distribution of correlation coefficient, regression coefficient, correlation ratio, intra class correlation coefficient. Categorical data analysis - loglinear models, Association between attributes. Variance Stabilizing Transformations.

UNIT V

Order statistics, distribution of *r* -th order statistics, joint distribution of several order statistics and their functions, marginal distributions of order statistics, distribution of range, median, etc.

Practical

Fitting of discrete distributions and test for goodness of fit; Fitting of continuous distributions and test for goodness of fit; Fitting of truncated distribution; Computation of simple, multiple and partial correlation coefficient, correlation ratio and intra-class correlation; Regression coefficients and regression equations; Fitting of Pearsonian curves; Analysis of association between attributes, categorical data and log-linear models.

Suggested Readings

- Agresti A. 2002. Categorical Data Analysis. 2nd Ed. John Wiley.
- Arnold BC, Balakrishnan N & Nagaraja HN. 1992. A First Course in Order Statistics. John Wiley.
- David HA & Nagaraja HN. 2003. Order Statistics. 3rd Ed. John Wiley.
- Dudewicz EJ & Mishra SN. 1988. Modern Mathematical Statistics. John Wiley.
- Huber PJ. 1981. Robust Statistics. John Wiley.
- Johnson NL, Kotz S & Balakrishnan N. 2000. Continuous Univariate Distributions. John Wiley.
- Johnson NL, Kotz S & Balakrishnan N. 2000. Discrete Univariate Distributions. John Wiley.
- Marek F. 1963. Probability Theory and Mathematical Statistics. John Wiley.
- Rao CR. 1965. Linear Statistical Inference and its Applications. John Wiley.
- Rohatgi VK & Saleh AK Md. E. 2005. An Introduction to Probability and Statistics. 2nd Ed. John Wiley.

AG. STAT. 562 : STATISTICAL INFERENCE 2+1

Objective

This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testing of hypothesis. They would also be given the concepts of nonparametric and sequential test procedures and elements of decision theory.

Theory

UNIT I

Concepts of point estimation: MSE, unbiasedness, consistency, efficiency and sufficiency. Statement of Neyman's Factorization theorem with applications. MVUE, Rao-Blackwell theorem, completeness, Lehmann-Scheffe theorem. Fisher information, Cramer-Rao lower bound and its applications.

UNIT II

Moments, minimum chi-square, least square and maximum likelihood methods of estimation and statements of their properties. Interval estimation-Confidence level, CI using pivots and shortest length CI. CI for the parameters of Normal, Exponential, Binomial and Poisson distributions.

UNIT III

Fundamental notions of hypothesis testing-statistical hypothesis, statistical test, critical region, types of errors, test function, randomized and non-randomized tests, level of significance, power function, most powerful tests: Neyman-Pearson fundamental lemma, MLR families and UMP tests for one parameter exponential families. Concepts of consistency, unbiasedness and invariance of tests. Likelihood Ratio tests, statement of asymptotic properties of LR tests with applications (including homogeneity of means and variances).Relation between confidence interval estimation and testing of hypothesis.

UNIT IV

Notions of sequential vs fixed sample size techniques. Wald's SPRT for testing simple null hypothesis vs simple alternative. Termination property of SPRT, SPRT for Binomial, Poisson, Normal and Exponential distributions. Concepts of loss, risk and decision functions, admissible and optimal decision functions, estimation and testing viewed as decision problems, conjugate families, Bayes and Minimax decision functions with applications to estimation with quadratic loss.

UNIT V

Non-parametric tests: Sign test, Wilcoxon signed rank test, Runs test for randomness, Kolmogorov – Smirnov test for goodness of fit, Median test and Wilcoxon-Mann-Whitney U-test. Chi-square test for goodness of fit and test for independence of attributes. Kruskal – Wallis and Friedman's tests. Spearman's rank correlation and Kendall's Tau tests for independence.

Practical

Methods of estimation - Maximum Likelihood, Minimum χ^2 and Moments; Confidence Interval Estimation; MP and UMP tests; Large Sample tests; Non-parametric tests, Sequential Probability Ratio Test; Decision functions.

Suggested Readings

- Box GEP & Tiao GC. 1992. Bayesian Inference in Statistical Analysis. John Wiley.
- Casela G & Berger RL. 2001. Statistical Inference. Duxbury Thompson Learning.
- Christensen R. 1990. Log Linear Models. Springer.
- Conover WJ. 1980. Practical Nonparametric Statistics. John Wiley.
- Dudewicz EJ & Mishra SN. 1988. Modern Mathematical Statistics. John Wiley.
- Gibbons JD. 1985. Non Parametric Statistical Inference. 2nd Ed. Marcel Dekker.
- Kiefer JC. 1987. Introduction to Statistical Inference. Springer.
- Lehmann EL. 1986. Testing Statistical Hypotheses. John Wiley.
- Lehmann EL. 1986. Theory of Point Estimation. John Wiley.
- Randles RH & Wolfe DS. 1979. Introduction to the Theory of Nonparametric Statistics. John Wiley.
- Rao CR. 1973. Linear Statistical Inference and its Applications. 2nd Ed. John Wiley.
- Rohatgi VK & Saleh AK. Md. E. 2005. An Introduction to Probability and Statistics. 2nd Ed. John Wiley.
- Rohtagi VK. 1984. Statistical Inference. John Wiley
- Sidney S & Castellan NJ Jr. 1988. Non Parametric Statistical Methods for Behavioral Sciences McGraw Hill.
- Wald A. 2004. *Sequential Analysis*. Dover Publ.

AG. STAT. 563 : MULTIVARIATE ANALYSIS 2+1

Objective

This course lays the foundation of Multivariate data analysis. Most of the data sets in agricultural sciences are multivariate in nature. The exposure provided to multivariate data structure, multinomial and multivariate normal distribution, estimation and testing of parameters, various data reduction methods would help the students in having a better understanding of agricultural research data, its presentation and analysis.

Theory

UNIT I

Concept of random vector, its expectation and Variance-Covariance matrix. Marginal and joint distributions. Conditional distributions and Independence of random vectors. Multinomial distribution. Multivariate Normal distribution, marginal and conditional distributions. Sample mean vector and its distribution. Maximum likelihood estimates of mean vector and dispersion matrix. Tests of hypothesis about mean vector.

UNIT II

Wishart distribution and its simple properties. Hotelling's T^2 and Mahalanobis D^2 statistics. Null distribution of Hotelling's T^2. Rao's U statistics and its distribution. Wilks' criterion and statement of its properties. Concepts of discriminant analysis, computation of linear discriminant function, classification between k ($k \geq 2$) multivariate normal populations based on LDF and Mahalanobis D^2.

UNIT III

Principal Component Analysis, factor analysis (simple and multi factor models). Canonical variables and canonical correlations. Cluster analysis, similarities and dissimilarities, Hierarchical clustering. Single and Complete linkage methods.

UNIT IV

Path analysis and computation of path coefficients, introduction to multidimensional scaling, some theoretical results, similarities, metric and non metric scaling methods. Concepts of analysis of categorical data.

Practical

Maximum likelihood estimates of mean-vector and dispersion matrix; Testing of hypothesis on mean vectors of multivariate normal populations; Cluster analysis, Discriminant function, Canonical correlation, Principal component analysis, Factor analysis; Multivariate analysis of variance and covariance, multidimensional scaling.

Suggested Readings

- Anderson TW. 1984. An Introduction to Multivariate Statistical Analysis. 2nd Ed. John Wiley.
- Arnold SF. 1981. The Theory of Linear Models and Multivariate Analysis. John Wiley.
- Giri NC. 1977. Multivariate Statistical Inference. Academic Press.
- Johnson RA & Wichern DW. 1988. Applied Multivariate Statistical Analysis. Prentice Hall.
- Kshirsagar AM. 1972. Multivariate Analysis. Marcel Dekker.
- Muirhead RJ. 1982. Aspects of Multivariate Statistical Theory. John Wiley.
- Rao CR. 1973. Linear Statistical Inference and its Applications. 2nd Ed. John Wiley.
- Rencher AC. 2002. Methods of Multivariate Analysis. 2nd Ed. John Wiley.
- Srivastava MS & Khatri CG. 1979. *An Introduction to Multivariate Statistics.* North Holland.

AG. STAT. 564 : DESIGN OF EXPERIMENTS 2+1

Objective

Design of Experiments provides the statistical tools to get maximum information from least amount of resources. This course is meant to expose the students to the basic principles of design of experiments. The students would also be provided with mathematical background of various basic designs involving one-way and two way elimination of heterogeneity and their characterization properties. This course would also prepare the students in deriving the expressions for analysis of experimental data.

Theory

UNIT I

Elements of linear estimation, Gauss Markoff Theorem, relationship between BLUEs and linear zero-functions. Aitken's transformation, test of hypothesis, analysis of variance, partitioning of degrees of freedom.

UNIT II

Orthogonality, contrasts, mutually orthogonal contrasts, analysis of covariance; Basic principles of design of experiments, uniformity trials, size and shape of plots and blocks.

UNIT III

Basic designs - completely randomized design, randomized complete block design and Latin square design; orthogonal Latin squares, mutually orthogonal Latin squares (MOLS), Youden square designs, Graeco Latin squares.

UNIT IV

Balanced incomplete block (BIB) designs – general properties and analysis without and with recovery of intra block information, construction of BIB designs. Partially balanced incomplete block designs with two associate classes - properties, analysis and construction, Lattice designs, alpha designs, cyclic designs, augmented designs, general analysis of block designs.

UNIT V

Factorial experiments, confounding in symmetr ical factorial experiments (2^n and 3^n series), partial and total confounding, fractional factorials,asymmetrical factorials.

UNIT VI

Designs for fitting response surface; Cross-over designs. Missing plot technique; Split plot and Strip plot design; Groups of experiments; Sampling in field experiments.

Practical

Determination of size and shape of plots and blocks from uniformity trials data; Analysis of data generated from completely randomized design, randomized complete block design; Latin square design, Youden square design; Analysis of data generated from a BIB design, lattice

design, PBIB designs; 2^n , 3^n factorial experiments without and with confounding; Split and strip plot designs, repeated measurement design; Missing plot techniques, Analysis of covariance; Analysis of Groups of experiments, Analysis of clinical trial experiments. Sampling in field experiments.

Suggested Readings

- Chakrabarti MC. 1962. Mathematics of Design and Analysis of Experiments. Asia Publ. House.
- Cochran WG & Cox DR. 1957. Experimental Designs. 2nd Ed. John Wiley.
- Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.
- Dey A & Mukerjee R. 1999. Fractional Factorial Plans. John Wiley.
- Dey A 1986. Theory of Block Designs. Wiley Eastern.
- Hall M Jr. 1986. Combinatorial Theory. John Wiley.
- John JA & Quenouille MH. 1977. Experiments: Design and Analysis. Charles & Griffin.
- Kempthorne, O. 1976. Design and Analysis of Experiments. John Wiley.
- Khuri AI & Cornell JA. 1996. Response Surface Designs and Analysis. 2nd Ed. Marcel Dekker.
- Kshirsagar AM 1983. A Course in Linear Models. Marcel Dekker.
- Montgomery DC. 2005. Design and Analysis of Experiments. John Wiley.
- Raghavarao D. 1971. Construction and Combinatorial Problems in Design of Experiments. John Wiley.
- Searle SR. 1971. Linear Models. John Wiley.
- Street AP & Street DJ. 1987. Combinatorics of Experimental Designs. Oxford Science Publ.
- Design Resources Server. Indian Agricultural Statistics Research Institute(ICAR), New Delhi-110012, India. www.iasri.res.in/design.

AG. STAT. 565 : SAMPLING TECHNIQUES 2+1

Objective

This course is meant to expose the students to the techniques of drawing representative samples from various populations and then preparing them on the mathematical formulations of estimating the population parameters based on the sample data. The students would also be exposed to the real life applications of sampling techniques and estimation of parameters.

Theory

UNIT I

Sample survey vs complete survey, probability sampling, sample space, sampling design, sampling strategy; Inverse sampling; Determination of sample size; Confidence-interval; Simple random sampling, Estimation of population proportion, Stratified random sampling, Number of strata and optimum points of stratification.

UNIT II

Ratio and regression methods of estimation, Cluster sampling, Systematic sampling, Multistage sampling with equal probability, Separate and combined ratio estimator, Double sampling, Successive sampling –two occasions**.**

UNIT III

Non-sampling errors – sources and classification, Non-response in surveys, Imputation methods, Randomized response techniques, Response errors – interpenetrating sub-sampling.

UNIT IV

Sampling with varying probabilities with and without replacement, PPS sampling, Cumulative method and Lahiri's method of selection, Horvitz-Thompson estimator, Ordered and unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran. Inclusion probability proportional to size sampling, PPS systematic sampling, Multistage sampling with unequal probabilities, Self weighting design PPS sampling.

UNIT V

Unbiased ratio and regression type estimators, Multivariate ratio and regression type of estimators, Design effect, Bernoulli and Poisson sampling.

Practical

Determination of sample size and selection of sample; Simple random sampling, Inverse sampling, Stratified random sampling, Cluster sampling, systematic sampling; Ratio and

regression methods of estimation; Double sampling, multi-stage sampling, Imputation methods; Randomized response techniques; Sampling with varying probabilities.

Suggested Readings

- Cassel CM, Sarndal CE & Wretman JH. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.
- Chaudhari A & Stenger H. 2005. *Survey Sampling Theory and Methods*. 2nd Ed. Chapman & Hall.
- Chaudhari A & Voss JWE. 1988. *Unified Theory and Strategies of Survey Sampling*. North Holland.
- Cochran WG. 1977. *Sampling Techniques*. John Wiley.
- Hedayat AS & Sinha BK. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.
- Kish L. 1965. *Survey Sampling*. John Wiley.
- Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Society, Calcutta.
- Raj D & Chandhok P. 1998. *Sample Survey Theory*. Narosa Publ.
- Sarndal CE, Swensson B & Wretman J. 1992. *Models Assisted Survey Sampling*. Springer.
- Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Thompson SK. 2000. *Sampling*. John Wiley.

AG. STAT. 566 STATISTICAL GENETICS - I 2+1

Objective

This course is meant to prepare the students in applications of statistics in quantitative genetics and breeding. The students would be exposed to the physical basis of inheritance, detection and estimation of linkage, estimation of genetic parameters and development of selection indices.

Theory

UNIT I

Physical basis of inheritance. Analysis of segregation, detection and estimation of linkage for qualitative characters. Amount of information about linkage, combined estimation, disturbed segregation.

UNIT II

Gene and genotypic frequencies, Random mating and Hardy -Weinberg law, Application and extension of the equilibrium law, Fisher's fundamental theorem of natural selection. Disequilibrium due to linkage for two pairs of genes, sex-linked genes, Theory of path coefficients.

UNIT III

Concepts of inbreeding, Regular system of inbreeding. Forces affecting gene frequency - selection, mutation and migration, equilibrium between forces in large populations, Random genetic drift, Effect of finite population size.

UNIT IV

Polygenic system for quantitative characters, concepts of breeding value and dominance deviation. Genetic variance and its partitioning, Effect of inbreeding on quantitative characters, Multiple allelism in continuous variation, Sex-linked genes, Maternal effects - estimation of their contribution.

UNIT V

Correlations between relatives, Heritability, Repeatability and Genetic correlation. Response due to selection, Selection index and its applications in plants and animals improvement programmes, Correlated response to selection.

UNIT VI

Restricted selection index. Variance component approach and linear regression approach for the analysis of GE interactions. Measurement of stability and adaptability for genotypes. Concepts of general and specific combining ability. Diallel and partial diallel crosses - construction and analysis.

Practical

Test for the single factor segregation ratios, homogeneity of the families with regard to single factor segregation; Detection and estimation of linkage parameter by different procedures; Estimation of genotypic and gene frequency from a given data. Hardy-Weinberg law; Estimation of changes in gene frequency due to systematic forces, inbreeding coefficient, genetic components of variation, heritability and repeatability coefficient, genetic correlation coefficient; Examination of effect of linkage, epistasis and inbreeding on mean and variance of metric traits; Mating designs; Construction of selection index including phenotypic index, restricted selection index. Correlated response to selection.

Suggested Readings

- Bailey NTJ. 1961. The Mathematical Theory of Genetic Linkage. Clarendon Press.
- Balding DJ, Bishop M & Cannings C. 2001. Hand Book of Statistical Genetics. John Wiley.
- Crow JF & Kimura M. 1970. An Introduction of Population Genetics Theory. Harper & Row.
- Dahlberg G. 1948. Mathematical Methods for Population Genetics. Inter Science Publ.
- East EM & Jones DF. 1919. Inbreeding and Outbreeding. J B Lippincott.
- Ewens WJ. 1979. Mathematics of Population Genetics. Springer.
- Falconer DS. 1985. Introduction to Quantitative Genetics. ELBL.
- Fisher RA. 1949. The Theory of Inbreeding. Oliver & Boyd.
- Fisher RA. 1950. Statistical Methods for Research Workers. Oliver & Boyd.
- Fisher RA. 1958. The Genetical Theory of Natural Selection. Dover Publ.
- Kempthorne O. 1957. An Introduction to Genetic Statistics. The Iowa State Univ. Press.
- Lerner IM. 1950. Population Genetics and Animal Improvement. Cambridge Univ. Press.
- Lerner IM. 1954. Genetic Homeostasis. Oliver & Boyd.
- Lerner IM. 1958. The Genetic Theory of Selection. John Wiley.
- Li CC. 1982. Population Genetics. The University of Chicago Press.
- Mather K & Jinks JL. 1977. Introduction to Biometrical Genetics. Chapman & Hall.
- Mather K & Jinks JL. 1982. Biometrical Genetics. Chapman & Hall.
- Mather K. 1949. Biometrical Genetics. Methuen.
- Mather K. 1951. The Measurement of Linkage in Heredity. Methuen.
- Narain P. 1990. Statistical *Genetics*. Wiley Eastern.

AG. STAT. 567 : REGRESSION ANALYSIS 1+1

Objective

This course is meant to prepare the students in linear and non-linear regression methods useful for statistical data analysis. They would also be provided a mathematical foundation behind these techniques and their applications in agricultural data.

Theory

UNIT I

Simple and Multiple linear regressions: Least squares fit, Properties and examples. Polynomial regression: Use of orthogonal polynomials.

UNIT II

Assumptions of regression; diagnostics and transformations; Examination of residuals ~ Studentized residuals, applications of residuals in detecting outliers, identification of influential observations. Lack of fit, Pure error.

Testing homoscedasticity and normality of errors, Durbin-Watson test. Use of R^2 for examining goodness of fit.

UNIT III

Concepts of Least median of squares and its applications; Concept of multicollinearity, Analysis of multiple regression models, estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation.

UNIT IV

Weighted least squares method: Properties, and examples. Box-Cox family of transformations. Use of dummy variables, Selection of variables: Forward selection, Backward elimination. Stepwise and Stagewise regressions.

UNIT V

Introduction to non-linear models, nonlinear estimation: Least squares for nonlinear models.

Practical

Multiple regression fitting with three and four independent variables; Estimation of residuals, their applications in outlier detection, distribution of residuals; Test of homoscedasticity, and normality, Box-Cox transformation; Restricted estimation of parameters in the model, hypothesis testing, Step wise regression analysis; Least median of squares norm, Orthogonal polynomial fitting.

Suggested Readings

- Barnett V & Lewis T. 1984. Outliers in Statistical Data. John Wiley.
- Belsley DA, Kuh E & Welsch RE. 2004. Regression Diagnostics-
- Identifying Influential Data and Sources of Collinearity. John Wiley.
- Chatterjee S, Hadi A & Price B. 1999. Regression Analysis by Examples. John Wiley.
- Draper NR & Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.
- McCullagh P & Nelder JA. 1999. Generalized Linear Models. 2nd Ed. Chapman & Hall.
- Montgomery DC, Peck EA & Vining GG. 2003. Introduction to Linear Regression Analysis. 3rd Ed. John Wiley.
- Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

AG. STAT. 568 : STATISTICAL COMPUTING 1+1

Objective

This course is meant for exposing the students in the concepts of computational techniques. Various statistical packages would be used for teaching the concepts of computational techniques.

Theory

UNIT I

Introduction to statistical packages and computing: data types and structures, pattern recognition, classification, association rules, graphical methods. Data analysis principles and practice

UNIT II

ANOVA, regression and categorical data methods; model formulation, fitting, diagnostics and validation; Matrix computations in linear models. Analysis of discrete data.

UNIT III

Numerical linear algebra, numerical optimization, graphical techniques, numerical approximations, numerical integration and Monte Carlo methods.

UNIT IV

Spatial statistics; spatial sampling; hierarchical modeling. Analysis of cohort studies, case-control studies and randomized clinical trials, techniques in the analysis of survival data and longitudinal studies, Approaches to handling missing data, and meta-analysis.

Practical

Data management, Graphical representation of data, Descriptive statistics; General linear models ~ fitting and analysis of residuals, outlier detection; Categorical data analysis, analysis of discrete data, analysis of binary data; Numerical algorithms; Spatial modeling, cohort studies; Clinical trials, analysis of survival data; Handling missing data.

Suggested Readings

- Agresti A. 2002. Categorical Data Analysis. 2nd Ed. John Wiley.
- Everitt BS & Dunn G. 1991. Advanced Multivariate Data Analysis. 2nd Ed. Arnold.
- Geisser S. 1993. Predictive Inference: An Introduction. Chapman & Hall.
- Gelman A & Hill J. 2006. Data Analysis Using Regression and Multilevel/Hierarchical Models. Cambridge Univ. Press.
- Gentle JE, Härdle W & Mori Y. 2004. Handbook of Computational Statistics - Concepts and Methods. Springer.
- Han J & Kamber M. 2000. Data Mining: Concepts and Techniques. Morgan.
- Hastie T, Tibshirani R & Friedman R. 2001. The Elements of Statistical Learning: Data Mining, Inference and Prediction. Springer.
- Kennedy WJ & Gentle JE. 1980. Statistical Computing. Marcel Dekker.
- Miller RG Jr. 1986. Beyond ANOVA, Basics of Applied Statistics. John Wiley.
- Rajaraman V. 1993. Computer Oriented Numerical Methods. Prentice-Hall.

- Ross S. 2000. Introduction to Probability Models. Academic Press.
- Ryan BF & Joiner BL. 1994. MINITAB Handbook. 3rd Ed. Duxbury Press.
- Simonoff JS. 1996. Smoothing Methods in Statistics. Springer.
- Snell EJ. 1987. Applied Statistics: A Handbook of BMDP Analyses. Chapman & Hall.
- Thisted RA. 1988. Elements of Statistical Computing. Chapman & Hall.
- Venables WN & Ripley BD. 1999. *Modern Applied Statistics With S-Plus*. 3rd Ed. Springer.

AG. STAT. 569 TIME SERIES ANALYSIS 1+1

Objective

This course is meant to teach the students the concepts involved in time series data. They would also be exposed to components of time series, stationary models and forecasting/ projecting the future scenarios based on time series data. It would also help them in understanding the concepts involved in time series data presentation, analysis and interpretation.

Theory

UNIT I

Components of a time-series. Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis.

UNIT II

Linear stationary models: Autoregressive, Moving average and Mixed processes. Linear non-stationary models: Autoregressive integrated moving average processes.

UNIT III

Forecasting: Minimum mean square forecasts and their properties, Calculating and updating forecasts.

UNIT IV

Model identification: Objectives, Techniques, and Initial estimates. Model estimation: Likelihood function, Sum of squares function, Least squares estimates. Seasonal models. Intervention analysis models and Outlier detection.

Practical

Time series analysis, autocorrelations, correlogram and periodogram; Linear stationary model; Linear non-stationary model; Model identification and model estimation; Intervention analysis and outliers detection.

Suggested Readings

- Box GEP, Jenkins GM & Reinsel GC. 2007. Time Series Analysis: Forecasting and Control. 3rd Ed. Pearson Edu.
- Brockwell PJ & Davis RA. 2002. Introduction to Time Series and Forecasting. 2nd Ed. Springer.
- Chatterjee S, Hadi A & Price B.1999. Regression Analysis by Examples. John Wiley.
- Draper NR & Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.
- Johnston J. 1984. Econometric Methods. McGraw Hill.
- Judge GG, Hill RC, Griffiths WE, Lutkepohl H & Lee TC. 1988. Introduction to the Theory and Practice of Econometrics. 2nd Ed. John Wiley.
- Montgomery DC & Johnson LA. 1976. Forecasting and Time Series Analysis. McGraw Hill.
- Shumway RH & Stoffer DS. 2006. Time Series Analysis and its Applications:With R Examples. 2nd Ed. Springer.

AG. STAT. 570 : ACTUARIAL STATISTICS 2+0

Objective

This course is meant to expose to the students to the statistical techniques such as probability models, life tables, insurance and annuities. The students would also be exposed top practical applications of these techniques in computation of premiums that include expenses, general expenses, types of expenses and per policy expenses.

Theory

UNIT I

Insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

UNIT II

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

UNIT III

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

UNIT IV

Distribution of aggregate claims, compound Poisson distribution and its applications.

UNIT V

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

UNIT VI

Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions.

UNIT VII

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

UNIT VIII

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

UNIT IX

Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

Suggested Readings

- Atkinson ME & Dickson DCM. 2000. An Introduction to Actuarial Studies. Elgar Publ.
- Bedford T & Cooke R. 2001. Probabilistic Risk Analysis. Cambridge.
- Booth PM, Chadburn RG, Cooper DR, Haberman S & James DE. 1999. Modern Actuarial Theory and Practice. Chapman & Hall.
- Borowiak Dale S. 2003. Financial and Actuarial Statistics: An Introduction. 2003. Marcel Dekker.
- Bowers NL, Gerber HU, Hickman JC, Jones DA & Nesbitt CJ. 1997. Actuarial Mathematics. 2nd Ed. Society of Actuaries, Ithaca, Illinois.
- Daykin CD, Pentikainen T & Pesonen M. 1994. Practical Risk Theory for Actuaries. Chapman & Hall.
- Klugman SA, Panjer HH, Willmotand GE & Venter GG. 1998. Loss Models: From data to Decisions. John Wiley.
- Medina PK & Merino S. 2003. Mathematical Finance and Probability: A Discrete Introduction. Basel, Birkhauser.
- Neill A. 1977. Life Contingencies. Butterworth-Heinemann.
- Rolski T, Schmidli H, Schmidt V & Teugels J. 1998. Stochastic Processes for Insurance and Finance. John Wiley.
- Rotar VI. 2006. Actuarial Models. The Mathematics of Insurance. Chapman & Hall/CRC.
- Spurgeon ET. 1972. *Life Contingencies*. Cambridge Univ. Press.

AG. STAT. 571 : BIOINFORMATICS 2+0

Objective

Bioinformatics is a new emerging area. It is an integration of Statistics, Computer applications and Biology. The trained manpower in the area of Bioinformatics is required for meeting the new challenges in teaching and research in the discipline of Agricultural Sciences. This course is meant to train the students on concepts of basic biology, statistical techniques and computational techniques for understanding bioinformatics principals.

Theory

UNIT I

Basic Biology: Cell, genes, gene structures, gene expression and regulation, Molecular tools, nucleotides, nucleic acids, markers, proteins and enzymes, bioenergetics, single nucleotide polymorphism, expressed sequence tag. Structural and functional genomics: Organization and structure of genomes, genome mapping, assembling of physical maps, strategies and techniques for genome sequencing and analysis.

UNIT II

Computing techniques: OS and Programming Languages – *Linux, perl* , *bioperl* , *cgi* , *MySQL* , *phpMyAdmin* ; Coding for browsing biological databases on web, parsing & annotation of genomic sequences; Database designing; Computer networks – Internet, World wide web, Web browsers – EMBnet, NCBI; Databases on public domain pertaining to Nucleic acid sequences, protein sequences, SNPs, etc.; Searching sequence databases, Structural databases.

UNIT III

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack-knifing; Hidden Markov Models; Bayesian estimation and Gibbs sampling;

UNIT IV

Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis, Approaches to EST analysis; Pairwise alignment techniques: Comparing two sequences, PAM and BLOSUM, Global alignment (The Needleman and Wunsch algorithm), Local Alignment (The Smith-Waterman algorithm), Dynamic programming, Pairwise database searching; Sequence analysis– BLAST and other related tools, Multiple alignment and database search using motif models, ClustalW, Phylogeny; Databases on SNPs; EM algorithm and other methods to discover common motifs in biosequences; Gene prediction based on Neural Networks, Genetic algorithms, Hidden Markov models. Computational analysis of protein sequence, structure and function; Design and Analysis of microarray experiments.

Suggested Readings

- Baldi P & Brunak S. 2001. Bioinformatics: The Machine Learning Approach. 2nd Ed. (Adaptive Computation and Machine Learning). MIT Press.
- Baxevanis AD & Francis BF. (Eds.). 2004. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. John Wiley.
- Bergeron BP. 2002. Bioinformatics Computing. Prentice Hall.
- Duda RO, Hart PE & Stork DG. 1999. Pattern Classification. John Wiley.
- Ewens WJ & Grant GR. 2001. Statistical Methods in Bioinformatics: An Introduction (Statistics for Biology and Health). Springer.
- Hunt S & Livesy F. (Eds.). 2000. Functional Genomics: A Practical Approach (The Practical Approach Series, 235). Oxford Univ. Press.
- Jones NC & Pevzner PA. 2004. An Introduction to Bioinformatics Algorithims. MIT Press.
- Koski T & Koskinen T. 2001. Hidden Markov Models for Bioinformatics. Kluwer.
- Krane DE & Raymer ML. 2002. Fundamental Concepts of Bio-informatics. Benjamin / Cummings.
- Krawetz SA & Womble DD. 2003. Introduction to Bioinformatics: A Theoretical and Practical Approach. Humana Press.
- Lesk AM. 2002. Introduction to Bio-informatics. Oxford Univ. Press.
- Percus JK. 2001. Mathematics of Genome Analysis. Cambridge Univ. Press.

- Sorensen D & Gianola D. 2002. Likelihood, Bayesian and MCMC Methods in Genetics. Springer.
- Tisdall JD. 2001. Mastering Perl for Bioinformatics. O'Reilly & Associates.
- Tisdall JD. 2003. B eginning Perl for Bioinformatics. O'Reilly & Associates.
- Wang JTL, Zaki MJ, Toivonen HTT & Shasha D. 2004. Data Mining in Bioinformatics. Springer.
- Wu CH & McLarty JW. 2000. Neural Networks and Genome Informatics. Elsevier.
- Wunschiers R. 2004. Computational Biology Unix/Linux, Data Processing and Programming. Springer.

AG. STAT. 572 : ECONOMETRICS 2+0

Objective

This course is meant for training the students in econometric methods and their applications in agriculture. This course would enable the students in understanding the economic phenomena through statistical tools and economics principles.

Theory

UNIT I

Representation of Economic phenomenon, relationship among economic variables, linear and non linear economic models, single equation general linear regression model, basic assumptions, Ordinary least squares method of estimation for simple and multiple regression models; summary statistics correlation matrix, co-efficient of multiple determination, standard errors of estimated parameters, tests of significance and confidence interval estimation. BLUE properties of Least Squares estimates. Chow test, test of improvement of fit through additional regressors. Maximum likelihood estimation.

UNIT II

Heteroscedasticity, Auto-correlation, Durbin Watson test, Multicollinearity. Stochastic regressors, Errors in variables, Use of instrumental variables in regression analysis. Dummy Variables. Distributed Lag models: Koyck's Geometric Lag scheme, Adaptive Expectation and Partial Adjustment Mode, Rational Expectation Models and test for rationality.

UNIT III

Simultaneous equation model: Basic rationale, Consequences of simultaneous relations, Identification problem, Conditions of Identification, Indirect Least Squares, Two-stage least squares, K-class estimators, Limited Information and Full Information Maximum Likelihood Methods, Three stage least squares, Generalized least squares, Recursive models, SURE Models. Mixed Estimation Methods, use of instrumental variables, pooling of cross-section and time series data, Principal Component Methods.

UNIT IV

Problem and Construction of index numbers and their tests; fixed and chain based index numbers; Construction of cost of living index number.

UNIT V

Demand analysis – Demand and Supply Curves; Determination of demand curves from market data. Engel's Law and the Engel's Curves, Income distribution and method of its estimation, Pareto's Curve, Income inequality measures.

Suggested Readings

- Croxton FE & Cowden DJ. 1979. Applied General Statistics. Prentice Hall of India.
- Johnston J. 1984. Econometric Methods. McGraw Hill.
- Judge GC, Hill RC, Griffiths WE, Lutkepohl H & Lee TC. 1988.
- Introduction to the Theory and Practice of Econometrics. 2nd Ed. John Wiley.
- Kmenta J. 1986. Elements of Econometrics. 2nd Ed. University of Michigan Press.
- Koop G. 2007. Introduction to Econometrics. John Wiley.
- Maddala GS. 2001. Introduction to Econometrics. 3rd Ed. John Wiley.
- Pindyck RS & Rubinfeld DL. 1998. Econometric Models and Economic Forecasts. 4th Ed. McGraw Hill.
- Verbeek M. 2008. *A Guide to Modern Econometrics*. 3rd Ed. John Wiley.

AG. STAT 573 : STATISTICAL QUALITY CONTROL 2+0

Objective

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agribusiness and agro-processing industries. This course would enable the students to have an idea about the statistical techniques used in quality control. students who do not have sufficient background of Statistical Methods.

Theory

UNIT I

Introduction to Statistical Quality Control; Control Charts for Variables – Mean, Standard deviation and Range charts; Statistical basis; Rational subgroups.

UNIT II

Control charts for attributes- 'np', 'p' and 'c' charts.

UNIT III

Fundamental concepts of acceptance, sampling plans, single, double and sequential sampling plans for attributes inspection.

UNIT IV

Sampling inspection tables for selection of single and double sampling plans.

Suggested Readings

- Cowden DJ. 1957. Statistical Methods in Quality Control. Prentice Hall of India.
- Dodge HF & Romig HG. 1959. Sampling Inspection Tables. John Wiley.
- Duncan A.J. 1986. Quality Control and Industrial Statistics. 5th Ed. Irwin Book Co.
- Grant EL & Leavenworth RS. 1996. Statistical Quality Control. 7th Ed. McGraw Hill.
- Montgomery DC. 2005. Introduction to Statistical Quality Control. 5th Ed. John Wiley.
- Wetherhil G.B. 1977. *Sampling Inspection and Quality Control*. Halsted Press.

AG. STAT. 574 : OPTIMIZATION TECHNIQUES 1+1

Objective

This course is meant for exposing the students to the mathematical details of the techniques for obtaining optimum solutions under constraints for desired output. They will be taught numerical methods of optimization, linear programming techniques, non-linear programming and multiple objective programming. Students will also be exposed to practical applications of these techniques.

Theory

UNIT I

Classical Optimization Techniques: Necessary Conditions for an Extremum. Constrained Optimization: Lagrange Multipliers, Statistical Applications. Optimization and Inequalities. Classical Inequalities, like Cauchy-Schwarz Inequality, Jensen Inequality and Markov Inequality.

UNIT II

Numerical Methods of Optimization: Numerical Evaluation of Roots of Equations, Direct Search Methods, Sequential Search Methods -- Fibonacci Search Method. Random Search Method – Method of Hooke and Jeeves, Simplex Search Method. Gradient Methods, like Newton's Method, and Method of Steepest Ascent. Nonlinear Regression and Other Statistical Algorithms, like Expectation – Maximization Algorithm.

UNIT III

Linear programming Techniques – Simplex Method, Karmarkar's Algorithm, Duality and Sensitivity Analysis. Zero-sum Two-person Finite Games and Linear Programming. Integer Programming. Statistical Applications.

UNIT IV

Nonlinear Programming and its Examples. Kuhn-Tucker Conditions. Quadratic Programming. Convex Programming. Basics of Stochastic Programming. Applications. Elements of Multiple Objective Programming. Dynamic Programming, Optimal Control Theory – Pontryagin's Maximum Principle, Time-Optimal Control Problems.

Practical

Problems based on classical optimization techniques; Problems based on optimization techniques with constraints; Minimization problems using numerical methods; Linear

programming (LP) problems through graphical method; LP problem by Simplex method; LP problem using simplex method (Two-phase method); LP problem using primal and dual method; Sensitivity analysis for LP problem; LP problem using Karmarkar's method; Problems based on Quadratic programming; Problems based on Integer programming; Problems based on Dynamic programming; Problems based on Pontryagin's Maximum Principle.

Suggested Readings

- Rao SS. 2007. Engineering Optimization: Theory and Practice. 3rd Ed. New Age.
- Rustagi JS. 1994. Optimization Techniques in Statistics. Academic Press.
- Taha HA. 2007. Operations Research: Introduction with CD. 8th Ed. Pearson Edu.
- Zeleny M. 1974. *Linear Multiobjective Programming*. Springer.

AG. STAT. 575 : DEMOGRAPHY 2+0

Objective

This course is meant for training the students in measures of demographic indices, estimation procedures of demographic parameters. Students would also be exposed to population projection techniques and principles involved in bioassays.

Theory

UNIT I

Introduction to vital statistics, crude and standard mortality and morbidity rates, Estimation of mortality, Measures of fertility and mortality, period and cohort measures.

UNIT II

Life tables and their applications, methods of construction of abridged life tables, Increment-Decrement Life Tables.

UNIT III

Stationary and stable populations, Migration and immigration. Application of stable population theory to estimate vital rates, migration and its estimation. Demographic relations in Nonstable populations. Measurement of population growth, Lotka's model (deterministic) and intrinsic rate of growth, Measures of mortality and morbidity, Period and

UNIT IV

Principle of biological assays, parallel line and slope ratio assays, choice of doses and efficiency in assays quantal responses, probit and logit transformations, epidemiological models.

Suggested Readings

- Cox DR. 1957. Demography. Cambridge Univ. Press.
- Finney DJ. 1981. Statistical Methods in Biological Assays. Charles Griffin.
- Fleiss JL. 1981. Statistical Methods for Rates and Proportions. John Wiley.
- Lawless JF. 1982. Statistical Models and Methods for Lifetime Data. John Wiley.
- MacMahon B & Pugh TF. 1970. Epidemiology- Principles and Methods. Little Brown, Boston.
- Mann NR, Schafer RE & Singpurwalla ND. 1974. Methods for Statistical Analysis of Reliability and Life Data. John Wiley.
- Newell C. 1988. Methods and Models in Demography. Guilford Publ.
- Preston S, Heuveline P & Guillot M. 2001. Demography: Measuring and Modeling Population Processes. Blackwell Publ.
- Rowland DT. 2004. Demographic Methods and Concepts. Oxford Press.
- Siegel JS & Swanson DA. 2004. The Methods and Material of Demography. 2nd Ed. Elsevier.
- Woolson FR. 1987. *Statistical Methods for the Analysis of Biomedical Data*. John Wiley.

AG. STAT. 576 : STATISTICAL METHODS FOR LIFE SCIENCES 2+0

Objective

This course focuses on statistical methods for discrete data collected in public health, clinical and biological studies including survival analysis. This would enable the students to understand the principles of different statistical techniques useful in public health and clinical studies conducted.

Theory

UNIT I

Proportions and counts, contingency tables, logistic regression models, Poisson regression and log-linear models, models for polytomous data and generalized linear models.

UNIT II

Computing techniques, numerical methods, simulation and general implementation of biostatistical analysis techniques with emphasis on data applications. Analysis of survival time data using parametric and non-parametric models, hypothesis testing, and methods for analyzing censored (partially observed) data with covariates. Topics include marginal estimation of a survival function, estimation of a generalized multivariate linear regression model (allowing missing covariates and/or outcomes).

UNIT III

Proportional Hazard model: Methods of estimation, estimation of survival functions, time-dependent covariates, estimation of a multiplicative intensity model (such as Cox proportional hazards model) and estimation of causal parameters assuming marginal structural models.

UNIT IV

General theory for developing locally efficient estimators of the parameters of interest in censored data models. Rank tests with censored data. Computing techniques, numerical methods, simulation and general implementation of biostatistical analysis techniques with emphasis on data applications.

UNIT V

Newton, scoring, and EM algorithms for maximization; smoothing methods; bootstrapping; trees and neural networks; clustering; isotonic regression; Markov chain Monte Carlo methods.

Suggested Readings

- Biswas S. 1995. Applied Stochastic Processes. A Biostatistical and Population Oriented Approach. Wiley Eastern Ltd.
- Collett D. 2003. Modeling Survival Data in Medical Research. Chapman & Hall.
- Cox DR & Oakes D. 1984. Analysis of Survival Data. Chapman & Hall.
- Hosmer DW Jr. & Lemeshow S. 1999. Applied Survival Analysis: Regression Modeling or Time to Event. John Wiley.
- Klein JP & Moeschberger ML. 2003. Survival Analysis: Techniques for Censored and Truncated Data. Springer.
- Kleinbaum DG & Klein M 2005. Survival Analysis. A Self Learning Text. Springer.
- Kleinbaum DG & Klein M. 2005. Logistic Regression. 2nd Ed. Springer.
- Lee ET. 1992. Statistical Methods for Survival Data Analysis. John Wiley.
- Miller RG. 1981. Survival Analysis. John Wiley.
- Therneau TM & Grambsch PM. 2000. Modeling Survival Data: Extending the Cox Model. Springer.

AG. STAT. 577 : STATISTICAL ECOLOGY 2+0

Objective

This course is meant for exposing the students to the importance and use of statistical methods in collections of ecological data, species-abundance relations, community classification and community interpretation.

Theory

UNIT I

Ecological data, Ecological sampling; Spatial pattern analysis: Distribution methods, Quadrant-variance methods, Distance methods.

UNIT II

Species-abundance relations: Distribution models, Diversity indices; Species affinity: Niche-overlap indices, interspecific association, interspecific covariation.

UNIT III

Community classification: Resemblance functions, Association analysis, Cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondence analysis, Nonlinear ordination.

UNIT IV

Community interpretation: Classification Interpretation and Ordination Interpretation.

Suggested Readings

- Pielou EC. 1970. An introduction to Mathematical Ecology. John Wiley.
- Reynolds JF & Ludwig JA. 1988. Statistical Ecology: A Primer on Methods and Computing. John Wiley.
- Young LJ, Young JH & Young J. 1998. *Statistical Ecology: A Population Perspective*. Kluwer.

AG.STAT. 578 : COMPUTER FUNDAMENTALS AND PROGRAMMING 2+1

Objective

This course builds an understanding of the structure of computers and how they execute programs, data representation and computer arithmetic. The course is also aimed to develop problem-solving strategies, techniques and skills to help students develop the logic, ability to solve the problems efficiently using C programming.

Theory

UNIT I

Introduction to Computers Definition of computer, its characteristics and uses. Classifications of computers, Number systems-decimal, octal, binary and hexadecimal. Representation of integers, fixed and floating point numbers, character representation-ASCII, EBCDIC, UNICODE.

UNIT II

Basic components of a computer: Central Processing Unit (CPU)- the control unit, arithmetic logic unit and register. Primary & secondary memories, Input and Output units, Operating system (OS) functions

UNIT III

Computer algorithms, Programming in C-Building blocks, Control structures, Arrays, Pointers, Dynamic memory allocation, File management. Over view of Data Structures, Linked List. Representation of integer, character, real, data types; Constants and variables; Arithmetic expressions, assignment statement, logical expression.

UNIT IV

Object Oriented Programming-Encapsulation, Inheritance, Polymorphism with C++/JAVA

Practical

Conversion of different number types; Creation of flow chart, conversion of algorithm/flowchart to program; Mathematical operators, operator precedence; Sequence, control and iteration; Arrays and string processing; Pointers and File processing.

Suggested Readings

- Balaguruswamy E. 1998. Programming with ANSI C. Tata McGraw Hill.
- Gottfried B. 1999. Programming with C, Schaum Outline Series. Tata McGraw Hill.
- Kanetkar Y. 1999. Let Us C. BPB Publ.
- Malvino AP & Brown JA. 1999. Digital Computer Electronics. Tata McGraw Hill.
- Mano MM. 1999. *Digital Logic and Computer Design*. Prentice Hall of India.

AG. STAT. 579 : INTRODUCTION TO NETWORKING AND INTERNET APPLICATIONS 1+1

Objective

The course is aimed to provide fundamentals of networking and application protocols with the emphasis on developing web based applications.

Theory

UNIT I

Networking fundamentals, types of networking, network topology; network operating system, Introduction to File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP).

UNIT II

World Wide Web (WWW), working with Internet; Hyper Text Markup Language (HTML), Building static and dynamic web pages, Client side and server side scripting Web pages, web sites, web servers; Web Applications.

UNIT III

Internet standards and services, Cryptography, Data compression, Authentication and Firewalls

Practical

Network and mail configuration; Using Network Services; Browsing of Internet; Creation of web pages; Creation of websites using HTML and Creation of websites using DHTML.

Suggested Readings

- Buyens J. 2002. Microsoft FrontPage -Inside Out. Microsoft Press.
- Cox V, Wermers L & Reding EE. 2006. HTML Illustrated Complete. 3rd Ed. Course Technology.
- Niederst J. 2001. Web Design in a Nutshell. O'Reilly Media.
- Tanenbaum AS. 2003. *Computer Networks*. Prentice Hall of India.

STAT 601 : ADVANCED STATISTICAL COMPUTING 2+1

Objective

This is an advanced course in Statistical Computing that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences and use of statistical packages.

Theory

UNIT I

Measures of association. Structural models for discrete data in two or more dimensions. Estimation in complete tables. Goodness of fit, choice of a model. Generalized Linear Model for discrete data, Poisson and Logistic regression models. Log-linear models.

UNIT II

Elements of inference for cross-classification tables. Models for nominal and ordinal response.

UNIT III

Computational problems and techniques for robust linear regression, nonlinear and generalized linear regression problem, tree-structured regression and classification, cluster analysis, smoothing and function estimation, robust multivariate analysis.

UNIT IV

Analysis of incomplete data: EM algorithm, single and multiple imputations. Markov Chain, Monte Carlo and annealing techniques, Neural Networks, Association Rules and learning algorithms.

UNIT V

Linear mixed effects models, generalized linear models for correlated data (including generalized estimating equations), computational issues and methods for fitting models, and dropout or other missing data.

UNIT VI

Multivariate tests of linear hypotheses, multiple comparisons, confidence regions, prediction intervals, statistical power, transformations and diagnostics, growth curve models, dose-response models.

Practical

Analysis of qualitative data; Generalized linear for correlated data; Generalized linear models for discrete data; Robust methods of estimation and testing of non-normal data; Robust multivariate analysis; Cluster analysis; Analysis of Incomplete data; Classification and prediction using artificial neural networks; Markov Chain; Analysis of data having random effects using Linear mixed effects models; Analysis of data with missing observations; Applications of multiple comparison procedures; Building Simultaneous confidence intervals; Fitting of growth curve models to growth data; Fitting of dose-response curves and estimation of parameters.

Suggested Readings

- Everitt BS & Dunn G. 1991. Advanced Multivariate Data Analysis. 2nd Ed. Arnold.
- Geisser S. 1993. Predictive Inference: An Introduction. Chapman & Hall.

- Gentle JE, Härdle W & Mori Y. 2004. Handbook of Computational Statistics -Concepts and Methods. Springer.
- Han J & Kamber M. 2000. Data Mining: Concepts and Techniques. Morgan.
- Hastie T, Tibshirani R & Friedman R. 2001. The Elements of Statistical Learning: Data Mining, Inference and Prediction. Springer.
- Kennedy WJ & Gentle JE. 1980. Statistical Computing. Marcel Dekker.
- Miller RG Jr. 1986. Beyond ANOVA, Basics of Applied Statistics. John Wiley.
- Rajaraman V. 1993. Computer Oriented Numerical Methods. Prentice-Hall.
- Robert CP & Casella G. 2004. Monte Carlo Statistical Methods. 2nd Ed. Springer.
- Ross S. 2000. Introduction to Probability Models. Academic Press.
- Simonoff JS. 1996. Smoothing Methods in Statistics. Springer.

- Thisted RA. 1988. Elements of Statistical Computing. Chapman & Hall.
- Venables WN & Ripley BD. 1999. Modern Applied Statistics With S-Plus. 3rd Ed. Springer.
- Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
- Design Resources Server: www.iasri.res.in.
- SAS Online Doc 9.1.3: http://support.sas.com/onlinedoc/913/docMainpage.jsp

AG. STAT. 602 : SIMULATION TECHNIQUES 1+1

Objective

This course is meant for students who have a good knowledge in Statistical Inference and Statistical Computing. This course would prepare students for undertaking research in the area of simulation techniques and their applications to agricultural sciences.

Theory

UNIT I

Review of simulation methods; Implementation of simulation methods - for various probability models, and resampling methods: theory and application of the jackknife and the bootstrap.

UNIT II

Randomization tests, analysis using computer software packages. Simulating multivariate distributions, MCMC methods and Gibbs sampler.

UNIT III

Correlograms, periodograms, fast Fourier transforms, power spectra, cross-spectra, coherences, ARMA and transfer-function models, spectral-domain regression. Simulated data sets to be analyzed using popular computer software packages

UNIT IV

Stochastic simulation: Markov Chain, Monte Carlo, Gibbs' sampling, Hastings-Metropolis algorithms, critical slowing-down and remedies, auxiliary variables, simulated tempering, reversible- jump MCMC and multi-grid methods.

Practical

Simulation from various probability models; Resampling methods, jackknife and the bootstrap; Randomization tests; Simulating multivariate distributions, MCMC methods and Gibbs sampler; Correlograms, periodograms, fast Fourier transforms, power spectra, cross-spectra, coherences; ARMA and transfer-function models, spectral-domain regression; Simulated data sets to be analyzed using popular computer software packages; Markov Chain, Monte Carlo, Gibbs' sampling; Reversible- jump MCMC and multi-grid methods.

Suggested Readings

- Averill ML, Kelton D. 2005. Simulation, Modeling and Analysis. Tata McGraw Hill.
- Balakrishnan N, Melas VB & Ermakov S. (Ed.). 2000. Advances inStochastic Simulation Methods. Basel-Birkhauser.
- Banks J. (Ed.). 1998. Handbook of Simulation: Principles, Methodology,
- Advances, Applications and Practice. John Wiley.
- Brately P, Fox BL & Scharge LE. 1987. A Guide to Simulation. Springer.
- Davison AC & Hinkley DV. 2003. Bootstrap Methods and their
- Application. Cambridge Univ. Press.
- Gamerman D, Lopes HF & Lopes HF. 2006. Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference. CRC Press.
- Gardner FM & Baker JD. 1997. Simulation Techniques Set. John Wiley.

- Gentle JE. 2005. Random Number Generation and Monte Carlo Methods. Springer.
- Janacek G & Louise S. 1993. Time Series: Forecasting, Simulation,
- Applications. Ellis Horwood Series in Mathematics and Its Applications.
- Kleijnen J & Groenendaal WV. 1992. Simulation: A Statistical Perspective. John Wiley.
- Kleijnen J. 1974 (Part I), 1975 (Part II). Statistical Techniques in
- Simulation. Marcel Dekker.
- Law A & Kelton D. 2000. Simulation Modeling and Analysis. McGraw Hill.
- Press WH, Flannery BP, Tenkolsky SA & Vetterling WT. 1986. Numerical Recipes. Cambridge Univ. Press.
- Ripley BD. 1987. Stochastic Simulation. John Wiley.
- Ross SM. 1997. *Simulation*. John Wiley.

AG. STAT. 611 : ADVANCED STATISTICAL METHODS 2+0

Objective

This is an advanced course in Statistical Methods that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

UNIT I

Ridge regression: Basic form, Use as a selection procedure. Robust regression: Least absolute deviations regression, M-estimators, Least median of squares regression. Nonparametric regression.

UNIT II

Introduction to the theory and applications of generalized linear models, fixed effects, random effects and mixed effects models, estimation of variance components from unbalanced data. Unified theory of least -squares, MINQUE, MIVQUE, REML.

UNIT III

Quasi-likelihoods, and generalized estimating equations - logistic regression, over-dispersion, Poisson regression, log-linear models, conditional likelihoods, generalized mixed models, and regression diagnostics. Theory of statistical methods for analyzing categorical data by means of linear models; multifactor and multi-response situations; interpretation of interactions.

UNIT IV

Fitting of a generalized linear model, mixed model and variance components estimation, MINQUE, MIVQUE, REML.

UNIT V

Fitting of Logistic regression, Poisson regression, ridge regression, robust regression, non-parametric regression.

Suggested Readings

- Chatterjee S, Hadi A & Price B.1999. Regression Analysis by Examples. John Wiley.
- Draper NR & Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.
- Rao CR. 1965. Linear Statistical Inference and its Applications. 2nd Ed. John Wiley.
- Searle SR, Casella G & McCulloch CE. 1992. Variance Components. John Wiley.
- Searle SR. 1971. *Linear Models*. John Wiley.

AG. STAT. 612 : ADVANCED STATISTICAL INFERENCE 3+0

Objective

This course aims at describing the advanced level topics in statistical methods and statistical inference. This course would prepare students to have a strong base in basic statistics that would help them in undertake basic and applied research in Statistics.

Theory

UNIT I

Robust estimation and robust tests, Robustness, M-estimates. L-estimates, asymptotic techniques, Bayesian inference. Detection and handling of outliers in statistical data.

UNIT II

Loglinear models, saturated models, hierarchical models, Analysis of multi - dimensional contingency tables. Non-parametric maximum likelihood estimation.

UNIT III

Density Estimation: Density Estimation in the Exploration and Presentation of Data. Survey of existing methods. The Kernel method for Univariate Data: Rosenblatts naïve estimator, its bias and variance. Consistency of general Kernel estimators, MSE and IMSE. Asymptotic normality of Kernel estimates of density. Estimation of distribution by method of kernels.

UNIT IV

Consistency and asymptotic normality (CAN) of real and vector parameters. Invariance of consistency under continuous transformation. Invariance of CAN estimators under differentiable transformations, generation of CAN estimators using central limit theorem. Exponential class of densities and multinomial distribution, Cramer-Huzurbazar theorem, method of scoring.

UNIT V

Efficiency: asymptotic relative efficiency and Pitman's theorem. Concepts and examples of Bahadur efficiency and Hodges-Lehmanns efficiency with examples. The concepts of Rao's second order efficiency and Hodges-Lehmann's Deficiency with examples. Rank tests, permutation tests, asymptotic theory of rank tests under null and alternative (contiguous) hypotheses.

UNIT VI

Inference on Markov Chains: Maximum likelihood estimation and testing of Transition Probability Matrix of a Markov Chain, testing for order of a Markov chain, estimation of functions of transition probabilities.

UNIT VII

Concept of loss, risk and decision functions, admissible and optimal decision functions, a-priori and posteriori distributions, conjugate families. Bayes and Minimax decision rules and some basic results on them. Estimation and testing viewed as cases of decision problems. Bayes and Minimax decision functions with applications to estimation with quadratic loss function. Concept of Bayesian sequential analysis. Bayes sequential decision rule. The SPRT as a Bayes procedure. Minimax sequential procedure.

UNIT VIII

U-Statistics: definitions of estimable parametric function, kernel, symmetric kernel and U-statistics. Variance and covariance of U-statistics. Hoeffding's decomposition of U-statistics – examples. U-statistics based on sampling from finite populations and weighted U-statistics with examples. Some convergence results on U-statistics. Asymptotic normality of U-statistics with examples.

UNIT IX

Resampling Plans : Estimation of standard and biased deviation of point estimator by the Jackknife, the Bootstrap, the Infinitesimal Jackknife, the Delta and the Influence function methods. Estimation of excess error in regression by cross validation, the Jackknife and Bootstrap methods. Nonparametric confidence interval for the median by the Percentile method.

Suggested Readings

- Casela G & Berger RL. 2001. Statistical Inference. Duxbury Thompson Learning.
- Daniel W.1990. Applied Nonparametric Statistics. Houghton Mifflin, Boston.
- DeGroot MH. 1970. Optimal Statistical Decisions. McGraw Hill.
- Efron B & Tibshirani RJ. 1993. An Introduction to Bootstrap. Chapman Hall/CRC.
- Ferguson TS. 1967. Mathematical Statistics, A Decision Theoretic Approach. Academic Press.
- Gibbons JD & Chakraborty S. 1992. Non-parametric Statistical Inference. Marcel Dekker.
- Gray HL & Schucany WR.1972. The Generalized Jackknife Statistics. Marcel Dekker.
- Kale BK.1999. A First Course on Parametric Inference. Narosa Publ.
- Prakasa Rao BLS. 1983. Nonparametric Functional Estimation. Academic Press.
- Rao CR.1965. Linear Statistical Inference and its Applications. 2nd Ed. John Wiley.
- Silverman BW. 1986. Density Estimation for Statistics and Data Analysis. Chapman & Hall.
- Silvey SD. 1975. Statistical Inference. Chapman & Hall.

- Tapia RA & Thompson JR. 1978. Nonparametric Probability Density Estimation. Johns Hopkins Univ. Press.
- Tiku ML, TanWY & Balakrishnana N. 1986. Robust Inference. Marcel Dekker.
- Wald A. 2004. Sequential Analysis. Dover Publ.
- Wasserman L. 2006. *All of Nonparametric Statistics*. Springer.

AG. STAT. 613 : ADVANCED DESIGN OF EXPERIMENTS 2+0

Objective

This is an advanced course in Design of Experiments that aims at describing some advanced level topics for students who wish to pursue research in Design of Experiments. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

UNIT I

General properties and analysis of block designs. Balancing criteria. *m*-associate PBIB designs, and their association schemes including lattice designs - properties and construction, Designs for test treatment – control(s) comparisons; Nested block designs, Mating designs.

UNIT II

General properties and analysis of two-way heterogeneity designs, Youden type designs, generalized Youden designs, Pseudo Youden designs. Structurally Incomplete block designs, Designs for two sets of treatments.

UNIT III

Balanced factorial experiments - characterization and analysis (symmetrical and asymmetrical factorials). Factorial experiments with extra treatment(s). Orthogonal arrays, Mixed orthogonal arrays, balanced arrays, Fractional replication, Regular and irregular fractions.

UNIT IV

Response surface designs - Symmetrical and asymmetrical factorials, Response optimization and slope estimation, Blocking. Canonical analysis and ridge analysis. Experiments with mixtures: design and analysis. Experiments with qualitative cum quantitative factors.

UNIT V

Optimality criteria and optimality of designs, robustness of designs against loss of data, outliers, etc. Diagnostics in design of experiments.

Suggested Readings

- Chakraborti MC. 1962. Mathematics of Design and Analysis of Experiments. Asia Publ. House.
- Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.
- Dey A & Mukerjee R. 1999. Fractional Factorial Plans. John Wiley.
- Dey A 1986. Theory of Block Designs. Wiley Eastern.
- Hall M Jr. 1986. Combinatorial Theory. John Wiley.
- Hedayat AS, Sloane NJA & Stufken J. 1999. Orthogonal Arrays: Theory and Applications. Springer.
- John JA & Quenouille MH. 1977. Experiments: Design and Analysis. Charles & Griffin.
- Khuri AI & Cornell JA. 1996. Response Surface Designs and Analysis. 2nd Ed. Marcel Dekker.
- Montgomery DC. 2005. Design and Analysis of Experiments. John Wiley.
- Ogawa J. 1974. Statistical Theory of the Analysis of Experimental Designs. Marcel Dekker.
- Parsad R, Gupta VK, Batra PK, Satpati SK & Biswas P. 2007. Monograph on a-designs. IASRI, New Delhi.
- Raghavarao D. 1971. Construction and Combinatorial Problems in Design of Experiments. John Wiley.
- Shah KR & Sinha BK. 1989. Theory of Optimal Designs. Lecture notes in Statistics. Vol. 54. Springer.
- Street AP & Street DJ. 1987. Combinatorics of Experimental Designs. Oxford Science Publ.
- Design Resources Server: www.iasri.res.in.

AG. STAT. 614 : ADVANCED SAMPLING TECHNIQUES 2+0

Objective

This is an advanced course in Sampling Techniques that aims at describing some advanced level topics for students who wish to pursue research in Sampling Techniques. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to Statistical System in the country.

Theory

UNIT I

Controlled selection. Two way stratification, collapsed strata. Systematic sampling in two dimensions. Use of combinatorics in controlled selection. Integration of surveys - Lahiri and Keyfitz's procedures.

UNIT II

Variance estimation in complex surveys. Taylor's series linearisation, balanced repeated replication, Jackknife and bootstrap methods.

UNIT III

Unified theory of sampling from finite populations. UMV - Non-existence theorem and existence theorem under restricted conditions. Concept of sufficiency and likelihood in survey sampling. Admissibility and hyper-admissibility.

UNIT IV

Inference under super population models - concept of designs and model unbiasedness, prediction approach. Regression analysis and categorical data analysis with data from complex surveys. Domain estimation. Small area estimation.

UNIT V

Stochastic parameter models, Bayes' linear predictor, Bayesian models with multi-stage sampling. Measurement error and small area estimation, Time series approach in survey sampling. Dynamic Bayesian prediction, Kalman filter, Empirical and Hierarchical Bayes predictors, Robust linear prediction, Bayesian robustness.

Suggested Readings

- Berger JO. 1993. Statistical Decision Theory and Bayesian Analysis. Springer.
- Bolfarine H & Zacks S. 1992. Prediction Theory for Finite Population Sampling. Springer.
- Cassel CM, Sarndal CE & Wretman JH. 1977. Foundations of Inference in Survey Sampling. John Wiley.
- Des Raj & Chandhok P. 1998. Sample Survey Theory. Narosa Publ. House.
- Ghosh M & Meeden G. 1997. Bayesian Method for Finite Population Sampling. Monograph on Statistics and Applied Probability. Chapman & Hall.
- Mukhopadhyay P. 1998. Theory and Methods of Survey Sampling. Prentice Hall of India.
- Rao JNK. 2003. Small Area Estimation. John Wiley.
- Sarndal CE, Swensson B & Wretman JH. 1992. *Model Assisted Survey Sampling*. Springer.

AG. STAT. 615 : ADVANCED STATISTICAL GENETICS 2+0

Objective

This is an advanced course in Statistical Genetics that aims at describing some advanced level topics for students who wish to pursue research in Statistical Genetics. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject in plant and animal breeding.

Theory

UNIT I

Genotype x environment interactions estimation of their contributions, non linear regression method for genotype x environment interactions. Nonparametric methods of stability analysis, AMMI Model for GxE interaction, clustering based on G x E, triallele and diallele method Restricted selection indices, combined selection with auxiliary traits. Partial diallel crosses (PDC) based on PBIB designs, and partial circulant structure, augmented PDCs. Optimal plans for PDCs. Triallel crosses, Double crosses. Mahalnobis D square analysis.

UNIT II

Methods of path co-efficient, Distribution of time until fixation, random fluctuations in selection intensity, stationary distribution of gene frequency. Effective population size.

UNIT III

Best linear unbiased prediction, Newer reproductive technology and its effect in genetic evaluation of individual merit. Estimation of genetic parameters - problems relating to computational aspects of genetic variance components, parameter estimation in variance component models for binary response data.

UNIT IV

Identification of genes with large effects, Use of molecular markers (RFLP, PCR-AFLP, RAPD and SSR), Gene mapping and Quantitative trait loci. Molecular manipulation for genetic variability.

Suggested Readings

- Crow JF & Kimura M. 1970. An Introduction of Population Genetics Theory. Harper & Row.
- Ewens WJ. 1979. Mathematical Population Genetics. Springer.
- Falconer DS. 1985. Introduction to Quantitative Genetics. ELBL.
- Fisher RA. 1949. The Theory of Inbreeding. Oliver & Boyd.
- Fisher RA. 1958. The Genetical Theory of Natural Selection. Dover Publ.
- Haldane JBS. 1932. The Causes of Evolution. Harper & Bros.
- Kempthorne O. 1957. An Introduction to Genetic Statistics. The Iowa State Univ. Press.
- Lerner IM. 1950. Population Genetics and Animal Improvement. Cambridge Univ. Press.
- Lerner IM. 1958. The Genetic Theory of Selection. John Wiley.
- Li CC. 1982. Population Genetics. The University of Chicago Press.
- Mather K & Jinks JL. 1982. Biometrical Genetics. Chapman & Hall.
- Mather K. 1951. The Measurement of Linkage in Heredity. Methuen.
- Nagilaki T. 1992. Introduction to Theoretical Population Genetics. Springer.
- Narain P. 1990. *Statistical Genetics*. Wiley Eastern.

AG. STAT. 616 : STATISTICAL MODELING 1+1

Objective

This is an advanced course in Statistical Methods that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in the area of empirical and mechanistic models and nonlinear estimation and the replications in different disciplines of agricultural sciences.

Theory

UNIT I

Empirical and mechanistic models. Nonlinear growth models like monomolecular, logistic, Gompertz, Richards. Applications in agriculture and fisheries.

UNIT II

Nonlinear estimation: Least squares for nonlinear models, Methods for estimation of parameters like Linearization, Steepest, and Levenberg-Marquardt's Reparameterization.

UNIT III

Two-species systems. Lotka-Volterra, Leslie-Gower and Holling-Tanner non-linear prey-predator models. Volterra's principle and its applications. Gause competition model.

UNIT IV

Compartmental modelling - First and second order input-output systems, Dynamics of a multivariable system.

Practical

Fitting of mechanistic non-linear models; Application of Schaefer and Fox non-linear models; Fitting of compartmental models.

Suggested Readings

- Draper NR & Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.
- Efromovich S. 1999. Nonparametric Curve Estimation. Springer.
- Fan J & Yao Q. 2003. Nonlinear Time Series-Nonparametric and Parametric Methods. Springer.
- France J & Thornley JHM. 1984. Mathematical Models in Agriculture. Butterworths.

- Harvey AC. 1996. Forecasting, Structural Time Series Models and the Kalman Filter. Cambridge Univ. Press.
- Ratkowsky DA. 1983. Nonlinear Regression Modelling: A Unified Practical Approach. Marcel Dekker.
- Ratkowsky DA. 1990. Handbook of Nonlinear Regression Models. Marcel Dekker.
- Seber GAF & Wild CJ. 1989. Non-linear Regression. John Wiley.
- Silverman BW. 1986. *Density Estimation for Statistics and Data Analysis*. Chapman & Hall.

AG. STAT. 617 : ADVANCED TIME SERIES ANALYSIS 2+0

Objective

This is an advanced course in Time Series Analysis that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

UNIT I

Multivariate time series: modelling the mean, stationary VAR models: properties, estimation, analysis and forecasting, VAR models with elements of nonlinearity, Non-stationary multivariate time series: spurious regression, co-integration, common trends.

UNIT II

Volatility: Modelling the variance, The class of ARCH models: properties, estimation, analysis and forecasting, stochastic volatility, realized volatility, Extensions: IGARCH, ARCH-t, ARCD, Multivariate GARCH, Time-varying risk and ARCH-in-mean.

UNIT III

Structural time-series modelling: State space models, Kalman filter. Local level model, Local linear trend model, Seasonal models, Cyclical models. Nonlinear time-series models: Parametric and nonparametric approaches. Autoregressive conditional heteroscedastic model and its extensions. Threshold and Functional coefficient autoregressive models.

UNIT IV

Non-linear programming, Kuhn-Tucker sufficient conditions, Elements of multiple objective programming, Dynamic Programming, Optimal control theory - Pontryagin's maximum principle, Time-optimal control problems.

Suggested Readings

- Box GEP, Jenkins GM & Reinsel GC. 2008. Time Series Analysis: Forecasting and Control. 3 Ed. John Wiley. rd
- Brockwell PJ & Davis RA. 1991. Time Series: Theory and Methods. 2nd Ed. Springer.
- Chatfield C. 2004. The Analysis of Time Series: An Introduction. 6th Ed. Chapman & Hall/CRC.
- Tong H. 1995. *Nonlinear Time Series: A Dynamical System Approach*. Oxford Univ. Press.

AG. STAT. 618 STOCHASTIC PROCESSES 2+0

Objective

This is a course on Stochastic Processes that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

UNIT I

Introduction to stochastic process - classification according to state space and time domain. Finite and countable state Markov chains; time-homogeneity; Chapman-Kolmogorov equations, marginal distribution and finite dimensional distributions. Classification of Markov chain. Canonical form of transition probability matrix of a Markov chain. Fundamental matrix; probabilities of absorption from transient states into recurrent classes in a finite Markov chain, mean time for absorption. Ergodic state
and Ergodic chain. Stationary distribution of a Markov chain, existence and evaluation of stationary distribution. Random walk and gamblers ruin problem.

UNIT II

Discrete state continuous time Markov process: Kolmogorov difference –differential equations. Birth and death process, pure birth process (Yule-Fury process). Immigration-Emigration process. Linear growth process, pure death process.

UNIT III

Renewal process: renewal process when time is discrete and continuous. Renewal function and renewal density. Statements of Elementary renewal theorem and Key renewal theorem.

UNIT IV

Stochastic process in biological sciences: Markov models in population genetics, compartmental analysis. Simple deterministic and stochastic epidemic model. General epidemic models-Karmack and McKendrick's threshold theorem. Recurrent epidemics.

UNIT V

Elements of queueing process; the queuing model M/M/1: steady state behaviors. Birth and death process in queuing theory- Multi channel models. Net work of Markovian queuing system.

UNIT VI

Branching process: Galton-Watson branching process. Mean and variance of size of nth generation, probability of ultimate extinction of a branching process. Fundamental theorem of branching process and applications.

UNIT VII

Wiener process- Wiener process as a limit of random walk. First passage time for Wiener process. Kolmogorov backward and forward diffusion equations and their applications.

Suggested Readings

- Adke SR & Manjunath SM. 1984. Finite Markov Processes. John Wiley.
- Bailey NTJ. 1964. Elements of Stochastic Processes with Applications to the Natural Sciences. Wiley Eastern.
- Bartlett MS. 1955. Introduction to Stochastic Processes. Cambridge Univ. Press.
- Basawa IV & Prakasa Rao BLS. 1980. Statistical Inference for Stochastic Processes. Academic Press.
- Bharucha-Reid AT. 1960. Elements of the Theory of Markov Processes and their Applications. McGraw Hill.
- Bhat BR. 2000. Stochastic Models; Analysis and Applications. New Age.
- Cox DR & Miller HD. 1965. The Theory of Stochastic Processes. Methuen.
- Draper NR & Smith H. 1981. Applied Regression Analysis. Wiley Eastern.
- France J & Thornley JHM. 1984. Mathematical Models in Agriculture. Butterworths.
- Karlin S & Taylor H.M. 1975. A First Course in Stochastic Processes. Vol. I. Academic Press.
- Lawler GF. 1995. Introduction to Stochastic Processes. Chapman & Hall.
- Medhi J. 2001. Stochastic Processes. 2nd Ed. Wiley Eastern.
- Parzen E. 1962. Stochastic Processes. Holden-Day.
- Prabhu NU. 1965. Stochastic Processes. Macmillan.
- Prakasa Rao BLS & Bhat BR.1996. Stochastic Processes and Statistical Inference. New Age.
- Ratkowsky DA. 1983. Nonlinear Regression Modelling: a Unified Practical Approach. Marcel Dekker.
- Ratkowsky DA. 1990. Handbook of Nonlinear Regression Models. Marcel Dekker.
- Seber GAF & Wild CJ. 1989. *Non-linear Regression*. John Wiley.

AG. STAT. 619 : SURVIVAL ANALYSIS 2+0

Objective

The course deals with the study of demographic profiles and survival times.In-depth statistical properties and analysis is an important component of this course.

Theory

UNIT I

Measures of Mortality and Morbidity: Ratios and proportions, rates of continuous process, rates of repetitive events ,crude birth rate, Mortality measures used in vital statistics relationships between crude and age specific rates, standardized mortality ratios ,evaluation of

person-year of exposed to risk in long term studies, prevalence and incidence of a disease, relative risk and odds ratio. Survival Distribution: Survival functions, hazard rate, hazard function, review of survival distributions: exponential, Weibull, Gamma, Rayleigh, Pareto, Lognormal~IFR and TFRA, Gompertz and Makeham. Gompertz and logistic distributions. Parametric (m.l.e) estimation. Types of Censoring: Type I, Type II, random and other types of censoring, right and left truncated distributions. Expectation and variance of future life time, series and parallel system of failures. Life Tables: Fundamental and construction.

UNIT II

Complete Mortality data, Estimation of Survival Function : Empirical survival function , estimation of survival function from grouped mortality data, joint distribution of the number of deaths, distribution of the estimation P_i covariance of estimate, estimation of curves of deaths and central death rate and force of mortality rate. Incomplete Mortality data (non-parametric models): Actuarial method, m.1.e method, moment and reduced sample method of estimation and their comparison. Product limit (Kaplan-Meier) method and cumulative hazard function (CHF) of estimation of survival function.

UNIT III

Fitting Parametric Survival Distribution : Special form of survival function cumulative hazard function (CHF) plots, Nelson's method of ungrouped data, construction of the likelihood function for survival data, least squares fitting, fitting a Gompertz distribution to grouped data. Some tests of Goodness of fit: Graphical, Kolmogorov-Smirnov statistics for complete, censored and truncated data, Chi-Square test and Anderson-Darling A^2-statistics. Comparison of Mortality Experiences: Comparison of two life tables, some distribution- free methods (two samples) for ungrouped data, Two samples Kolmogorov-Smirnov test, Wilcoxon test for complete data and modified Wilcoxon test for incomplete data.Gilbert and Gehan's test, mean and variance of Wilcoxon statistics, generalization of Gehan's test. Testing for
Consistent Differences in Mortality : Mantel-Haenszel and log rank test. Generalized Mantel-Haenszel test (k-sample).

UNIT IV

Concomitant Variables: General parametric model for hazard function with observed concomitant variables. Additive and multiplicative models of hazard rate functions. Estimating multiplicative models, selection of concomitant variables. Logistic linear model, Concomitant Variable regarded as random variable. Age of onset distributions: Models of onset distributions and their estimation. Gompertz distribution, parallel system and Weibull distribution, Fatal short models of failure. Two component series system.

Suggested Readings

- Anderson B. 1990. Methodological Errors in Medical Research. Blackwell.
- Armitage P & Berry G. 1987. Statistical Methods in Medical Research.Blackwell.
- Collett D. 2003. Modeling Survival Data in Medical Research. Chapman & Hall.
- Cox DR & Oakes D. 1984. Analysis of Survival Data. Chapman & Hall.
- Elandt-Johnson RC & Johnson NL. 1980. Survival Models and Data Analysis. John Wiley.
- Everitt BS & Dunn G. 1998. Statistical Analysis of Medical Data. Arnold.
- Hosmer DW Jr. & Lemeshow S. 1999. Applied Survival Analysis: Regression Modeling or Time to Event. John Wiley.
- Kalbfleisch JD & Prentice. RL 2002. The Statistical Analysis of Failure Time Data. John Wiley.
- Klein JP & Moeschberger ML. 2003. Survival Analysis: Techniques forCensored and Truncated Data. Springer.
- Kleinbaum DG & Klein M. 2002. Logistic Regression. Springer.
- Kleinbaum DG & Klein M. 2005. Survival Analysis. Springer.
- Lawless JF. 2003. Statistical Models and Methods for Lifetime Data. 2nd Ed. John Wiley.
- Lee ET. 1980. *Statistical Methods for Survival Data Analysis*. Lifetime Learning Publ.

AG. STAT. 620 : ADVANCED BIOINFORMATICS 2+0

Objective

This is a course on Bioinformatics that aims at exposing the students to some advanced statistical and computational techniques related to bioinformatics. This course would prepare the students in understanding bioinformatics principles and their applications.

Theory

UNIT I

Genomic databases and analysis of high-throughput data sets, sequence annotation, ESTs, SNPs. BLAST and related sequence comparison methods. EM algorithm and other statistical methods to discover common motifs in biosequences. Multiple alignment and database search using motif models, ClustalW and others. Concepts in phylogeny. Gene prediction based on codons, Decision trees, Classificatory analysis, Neural Networks, Genetic algorithms, Pattern recognition, Hidden Markov models.

UNIT II

Computational analysis of protein sequence, structure and function. Expression profiling by microarray/gene chip, proteomics etc., Multiple alignment of protein sequences, Modelling and prediction of structure of proteins, Designer proteins, Drug designing.

UNIT III

Analysis of one DNA sequence (Modeling signals in DNA; Analysis of patterns; Overlaps and Generalizations), Analysis of multiple DNA or protein sequences (Alignment algorithms – Gapped global comparisons and Dynamic programming; use of linear gap models; protein sequences and substitution matrices – BLOSUM, PAM; Multiple sequences), BLAST (Comparison of two aligned sequences – Parameter calculation; Choice of a score; Bounds for P-value; Normalized and Bit scores, Karlin – Altschul sum statistic; comparison of two unaligned sequences; Minimum significance Lengths).

UNIT IV

Markov chains (MC with no absorbing states; Higher order Markov dependence; patterns in sequences; Markov chain Monte Carlo – Hastings-Metropolis algorithm, Gibbs sampling, Simulated Annealing; MC with absorbing States, Continuous-Time Markov chains) Hidden Markov Models (Forward and Backward algorithm; Viterbi algorithms; Estimation algorithm;

UNIT V

Modeling protein families; Multiple sequence alignments; Pfam; Gene finding), Computationally intensive methods (Classical estimation methods; Bootstrap estimation and Confidence Intervals; Hypothesis testing; Multiple Hypothesis testing), Evolutionary models (Models of Nucleotide substitution; Discrete time models – The Jukes-Cantor Model, The Kimura Model, The Felsenstein Model; Continuous-time models),

UNIT VI

Phylogenetic tree estimation (Distances; Tree reconstruction – Ultrametric and Neighbor-Joining cases; Surrogate distances; Tree reconstruction; Parsimony and Maximum Likelihood; Modeling, Estimation and Hypothesis Testing;) Neural Networks (Universal Approximation Properties; Priors and Likelihoods, Learning Algorithms – Backpropagation; Sequence encoding and output interpretation; Prediction of Protein Secondary Structure; Prediction of Signal Peptides and their cleavage sites; Application for DNA and RNA Nucleotide Sequences), Analysis of SNPs and Haplotypes.

Suggested Readings

- Baldi P & Brunak S. 2001. Bioinformatics: The Machine Learning Approach. MIT Press.
- Baxevanis AD & Francis BF. (Eds.). 2004. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. John Wiley.
- Duda RO, Hart PE & Stork DG. 1999. Pattern Classification. John Wiley.
- Ewens WJ & Grant GR. 2001. Statistical Methods in Bioinformatics. Springer.
- Jones NC & Pevzner PA. 2004. Introduction to Bioinformatics Algorithims. The MIT Press.
- Koskinen T. 2001. Hidden Markov Models for Bioinformatics. Kluwer.
- Krane DE & Raymer ML. 2002. Fundamental Concepts of Bio-informatics.Benjamin / Cummings.
- Krawetz SA & Womble DD. 2003. Introduction to Bioinformatics: A Theoretical and Practical Approach. Humana Press.
- Lesk AM. 2002. Introduction to Bio-informatics. Oxford Univ. Press.
- Linder E & Seefeld K. 2005. R for Bioinformatics. O'Reilly & Associates.
- Percus JK. 2001. Mathematics of Genome Analysis. Cambridge Univ. Press.
- Sorensen D & Gianola D. 2002. Likelihood, Bayesian and MCMC Methods in Genetics. Springer.
- Tisdall JD. 2001. Mastering Perl for Bioinformatics. O'Reilly & Associates.

- Wang JTL, Zaki MJ, Toivonen HTT & Shasha D. 2004. Data Mining in Bioinformatics. Springer.
- Wu CH & McLarty JW. 2000. Neural Networks and Genome Informatics. Elsevier.
- Wunschiers R. 2004. Computational Biology Unix/Linux, Data Processing and Programming. Springer.
- Yang MCC. 2000. *Introduction to Statistical Methods in Modern Genetics*. Taylor & Francis.

AG. STAT. 621 ADVANCED ECONOMETRICS 2+0

Objective

This is a course on Econometrics aims at exposing the students to some advanced level econometric methods and their applications to agricultural situations.

Theory

UNIT I

Quantile regression, binary quantile regression, extreme values, copula, loss functions, Point and interval forecasting, unconditional and conditional forecasting, forecasting with serially correlated errors, bootstrap: asymptotic expansion, bootstrap consistency, asymptotic refinement, recent developments for dependent time series

UNIT II

Multivariate time series: modelling the mean, stationary VAR models: properties, estimation, analysis and forecasting, VAR models with elements of nonlinearity, Non-stationary multivariate time series: spurious regression, co-integration, common trends; Volatility: Modelling the variance, The class of ARCH models: properties, estimation, analysis and forecasting, stochastic volatility, realized volatility.

UNIT III

Basic Concepts of Bayesian Inference, Probability and Inference, Posterior Distributions and Inference, Prior Distributions. The Bayesian linear model and autoregressive (AR) processes; Model selection with marginal likelihoods and fractional priors, Comparison of Bayesian Methods with Classical approaches, Bayes risk and their applications, and Sample Selection Monte Carlo integration, importance sampling and Gibbs sampling, The Regression Model with General Error Covariance Matrix, Qualitative Choice Models, Bayesian information criterion (BIC), Markov Chain Monte Carlo (MCMC) Model Composition and stochastic search variable selection, BUGS [Bayesian Inference Using Gibbs Sampling] , BUCC [Bayesian Analysis, Computation and Communication].

Suggested Readings

- Banerjee A, Dolado J, Galbraith J & Hendry DF. 1993. Co-integration, Error Correction, and the Econometric Analysis of Nonstationary Data. Oxford Univ. Press.
- Bauwens L, Lubrano M & Richard JF. 1999. Bayesian Inference in Dynamics of Econometric Models. Oxford Univ. Press.
- Carlin BP & Louis TA. 1996. Bayes and Empirical Bayes Methods for Data Analysis. Chapman & Hall.
- Gilks WR, Richardson S & Spiegelhalter D. 1996. MCMC in Practice.Chapman & Hall.
- Greenberg E. 2008. Introduction to Bayesian Econometrics. Cambridge Univ. Press.
- Hamilton JD. 1994. Time Series Analysis. Princeton Univ. Press.
- Judge GG, Griffith WE, Hill RC, Lee CH & Lutkepohl H. 1985. The Theory and Practice of Econometrics. 2nd Ed. John Wiley.
- Koop G, Poirier D & Tobias J. 2007. Bayesian Econometric Methods. Cambridge Univ. Press.
- Koop G. 2003. Bayesian Econometrics. John Wiley.
- Lancaster A. 2004. An Introduction to Modern Bayesian Econometrics. Blackwell.
- Pindyck RS & Rubinfeld DL. 1981. Econometric Models and Economic Forecasts. McGraw Hill.

AG. STAT. 651 : RECENT ADVANCES IN THE FIELD OF SPECIALIZATION 1+0

Objective

To familiarize the students with the recent advances in the areas of their specialization to prepare them for undertaking research.

Theory

Recent advances in the field of specialization - sample surveys / design of experiments /statistical genetics / statistical modeling / econometrics / statistical inference, etc. will be covered by various speakers from the University / Institute as well as from outside the University / Institute in the form of seminar talks.

FRUIT SCIENCE

FSC 501 : TROPICAL AND DRY LAND FRUIT PRODUCTION 2+1

Objective

To impart basic knowledge about the importance and management of tropical and dry land fruits grown in India.

Theory

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bioregulators, abiotic factors limiting fruit production, physiology of flowering, pollination fruit set and development, honeybees in cross pollination, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones(AEZ) and industrial supports.

Crops

UNIT I: Mango and Banana
UNIT II: Citrus and Papaya
UNIT III: Guava, Sapota and Jackfruit
UNIT IV: Pineapple, Annonas and Avocado
UNIT V: Aonla, Pomegranate and Ber, minor fruits of tropics

Practical

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical and arid zone orchards, Project preparation for establishing commercial orchards.

Suggested Readings

- Bose TK, Mitra SK & Rathore DS. (Eds.). 1988. Temperate Fruits - Horticulture. Allied Publ.
- Bose TK, Mitra SK & Sanyal D. 2001. (Eds.). Fruits -Tropical and Subtropical. Naya Udyog.
- Chadha KL & Pareek OP. 1996. (Eds.). Advances in Horticulture. Vols. IIIV. Malhotra Publ. House.
- Nakasone HY & Paul RE. 1998. Tropical Fruits. CAB I.
- Peter KV. 2008. (Ed.). Basics of Horticulture. New India Publ. Agency.
- Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008.
- Management of Horticultural Crops. Parts I, II. New India Publ. Agency.
- Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency.
- Singh HP, Negi JP & Samuel JC. (Eds.). 2002. Approaches for Sustainable Development of Horticulture. National Horticultural Board.
- Singh HP, Singh G, Samuel JC & Pathak RK. (Eds.). 2003. Precision Farming in Horticulture. NCPAH, DAC/PFDC, CISH, Lucknow.

FSC 502 : SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION 2+1

Objective

To impart basic knowledge about the importance and management of subtropical and temperate fruits grown in India.

Theory

Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, bioregulation, abiotic factors limiting fruit production, physiology of flowering, fruit set and development, abiotic factors limiting production, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, precooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones(AEZ) and industrial support.

Crops

UNIT I: Apple, pear, quince, grapes
UNIT II: Plums, peach, apricot, cherries
UNIT III: Litchi, loquat, persimmon, kiwifruit, strawberry
UNIT IV: Nuts- walnut, almond, pistachio, pecan, hazelnut
UNIT V: Minor fruits- mangosteen, carambola, bael, wood apple, fig, jamun, rambutan, pomegranate

Practical

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical, subtropical, humid tropical and temperate orchards, Project preparation for establishing commercial orchards.

Suggested Readings

- Bose TK, Mitra SK & Sanyol D. (Ed.). 2002. *Fruits of India – Tropical and Sub-tropical*. 3rd Ed. Vols. I, II. Naya Udyog.
- Chadha KL & Pareek OP. 1996. (Eds.). Advances in Horticulture. Vol. I. Malhotra Publ. House.
- Chadha KL & Shikhamany SD. 1999. The Grape: Improvement, Production and Post-Harvest Management. Malhotra Publ. House.
- Janick J & Moore JN. 1996. Fruit Breeding. Vols.I-III. John Wiley & Sons.
- Nijjar GS. 1977. (Eds.). Fruit Breeding in India. Oxford & IBH.
- Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency.
- Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. Advances in Citriculture. Jagmander Book Agency.

FSC 503 : BIODIVERSITY AND CONSERVATION OF FRUIT CROPS 2+1

Objective

Understanding the principles of biodiversity and strategies in germplasm conservation of fruit crops.

Theory

UNIT I

Biodiversity and conservation; issues and goals, centres of origin of cultivated fruits; primary and secondary centres of genetic diversity.

UNIT II

Present status of gene centres; exploration and collection of germplasm; conservation of genetic resources – conservation *in situ* and *ex situ.*

UNIT III

Germplasm conservation- problem of recalcitrancy - cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine.

UNIT IV

Intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group.

UNIT V

GIS and documentation of local biodiversity, Geographical indication.

Crops

Mango, sapota, citrus, guava, banana, papaya, grapes, jackfruit, custard, apple, ber, aonla, malus, *Prunus* sp, litchi, nuts, coffee, tea, rubber, cashew, coconut, cocoa, palmyrah, arecanut, oil palm and betelvine.

Practical

Documentation of germplasm – maintenance of passport data and other records of accessions; field exploration trips, exercise on *ex situ* conservation – cold storage, pollen/seed storage, cryopreservation, visits to National Gene Bank and other centres of PGR activities. Detection of genetic constitution of germplasm, core sampling, germplasm characterization using molecular techniques.

Suggested Readings

- Frankel OH & Hawkes JG. 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press.
- Peter KV & Abraham Z. 2007. Biodiversity in Horticultural Crops. Vol. I. Daya Publ. House.
- Peter KV. 2008. Biodiversity of Horticultural Crops. Vol. II. Daya Publ. House.

FSC 504 : CANOPY MANAGEMENT IN FRUIT CROPS 1+1

Objective

To impart knowledge about the principles and practices in canopy management of fruit crops.

Theory

UNIT I

Canopy management - importance and advantages; factors affecting canopy development.

UNIT II

Canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies.

UNIT III

Spacing and utilization of land area - Canopy classification; Canopy management through rootstock and scion.

UNIT IV

Canopy management through plant growth inhibitors, training and pruning and management practices.

UNIT V

Canopy development and management in relation to growth, flowering, fruiting and fruit quality in temperate fruits, grapes, passion fruits, mango, sapota, guava, citrus and ber.

Practical

Study of different types of canopies, training of plants for different canopy types, canopy development through pruning, use of plant growth inhibitors, geometry of planting; study on effect of different canopy types on production and quality of fruits.

Suggested Readings

- Chadha KL & Shikhamany SD. 1999. The Grape, Improvement, Production and Post Harvest Management. Malhotra Publ. House.
- Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. Management of Horticultural Crops. New India Publ. Agency.

FSC 505 : PROPAGATION AND NURSERY MANAGEMENT FOR FRUIT CROPS 2+1

Objective

Familiarization with principles and practices of propagation and nursery management for fruit crops.

Theory

UNIT I

Introduction, life cycles in plants, cellular basis for propagation, sexual propagation, apomixis, polyembryony, chimeras. Principles factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth.

UNIT II

Seed quality, packing, storage, certification, testing. Asexual propagation –rooting of soft and hard wood cutting under mist by growth regulators. Rooting of cuttings in hotbeds. Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

UNIT III

Budding and grafting – selection of elite mother plants. Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility. Rejuvenation through top working – Progeny orchard and scion bank.

UNIT IV

Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques - *in vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture. Hardening, packing and transport of micro-propagules.

UNIT V

Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production.

Practical

Anatomical studies in rooting of cutting and graft union, construction of propagation structures, study of media and PGR. Hardening – case studies, micropropagation, explant preparation, media preparation, culturing – *in vitro* clonal propagation, meristem culture, shoot tip culture, axillary bud culture, direct organogenesis, direct and indirect embryogenesis, micro grafting, hardening. Visit to TC labs and nurseries.

Suggested Readings

- Hartmann HT & Kester DE. 1989. Plant Propagation – Principles and Practices. Prentice Hall of India.
- Bose TK, Mitra SK & Sadhu MK. 1991. Propagation of Tropical and Subtropical Horticultural Crops. Naya Prokash.
- Peter KV. (Ed.). 2008. Basics of Horticulture. New India Publ. Agency.
- Singh SP. 1989 Mist Propagation. Metropolitan Book Co.
- Rajan S & Baby LM. 2007. Propagation of Horticultural Crops. New India Publ. Agency.
- Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

FSC 506 : BREEDING OF FRUIT CROPS 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of fruit crops.

Theory

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, ideotypes, approaches for crop improvement - introduction, selection, hybridization, mutation breeding, polyploidy breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops.

Crops

UNIT I : Mango, banana and pineapple
UNIT II: Citrus, grapes, guava and sapota
UNIT III: Jackfruit, papaya, custard apple, aonla, avocado and ber
UNIT IV: Mangosteen, litchi, jamun, phalsa, mulberry, raspberry, kokam and nuts
UNIT V: Apple, pear, plums, peach, apricot, cherries and strawberry

Practical

Characterization of germplasm, blossom biology, study of anthesis, estimating fertility status, practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for resistance, developing breeding programme for specific traits, visit to research stations working on tropical, subtropical and temperate fruit improvement.

Suggested Readings

- Bose TK, Mitra SK & Sanyol D. (Eds.). 2002. Fruits of India – Tropical and Sub-tropical. 3rd Ed. Vols. I, II. Naya Udyog.
- Chadha KL & Pareek OP. 1996. (Eds.). Advances in Horticulture. Vol. I. Malhotra Publ. House.
- Chadha KL & Shikhamany SD. 1999. The Grape: Improvement, Production and Post-Harvest Management. Malhotra Publ. House.
- Janick J & Moore JN. 1996. Fruit Breeding. Vols.I-III. John Wiley & Sons.
- Nijjar GS. 1977. (Eds.). Fruit Breeding in India. Oxford & IBH.
- Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency.
- Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. Advances in Citriculture. Jagmander Book Agency.

FSC 507 : POST HARVEST TECHNOLOGY FOR FRUIT CROPS 2+1

Objective

To facilitate deeper understanding on principles and practices of postharvest management of fruit crops.

Theory

UNIT I

Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration.

UNIT II

Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling.

UNIT III

Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storageventilated, refrigerated, MAS, CA storage, physical injuries and disorders.

UNIT IV

Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies.

UNIT V

Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

Practical

Analyzing maturity stages of commercially important horticultural crops, improved packing and storage of important horticultural commodities, physiological loss in weight of fruits and vegetables, estimation of transpiration, respiration rate, ethylene release and study of vase life extension in cut flower using chemicals, estimation of quality characteristics in stored fruits and vegetables, cold chain management - visit to cold storage and CA storage units, visit to fruit and vegetable processing units, project preparation, evaluation of processed horticultural products.

Suggested Readings

- Bhutani RC. 2003. Fruit and Vegetable Preservation. Biotech Books.
- Chadha KL & Pareek OP. (Eds.). 1996 Advances in Horticulture. Vol. IV. Malhotra Publ. House.
- Haid NF & Salunkhe SK. 1997. Post Harvest Physiology and Handling of Fruits and Vegetables. Grenada Publ.
- Mitra SK. 1997. Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruits. CABI.
- Ranganna S. 1997. Hand Book of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill.
- Sudheer KP & Indira V. 2007. Post Harvest Technology of Horticultural Crops. New India Publ. Agency.
- Willis R, Mc Glassen WB, Graham D & Joyce D. 1998. Post Harvest. An Introduction to the Physiology and Handling *of Fruits, Vegetables and Ornamentals*. CABI.

FSC 508 : GROWTH AND DEVELOPMENT OF HORTICULTURAL CROPS 2+1

Objective

To develop understanding of growth and development of horticultural crops which have implications in their management.

Theory

UNIT I

Growth and development- definition, parameters of growth and development, growth dynamics, morphogenesis.

UNIT II

Annual, semi-perennial and perennial horticultural crops, environmental impact on growth and development, effect of light, photosynthesis and photoperiodism vernalisation, effect of temperature, heat units, thermoperiodism.

UNIT III

Assimilate partitioning during growth and development, influence of water and mineral nutrition during growth and development, biosynthesis of auxins, gibberellins, cytokinins, abscissic acid, ethylene, brassino-steroids, growth inhibitors, morphactins, role of plant growth promoters and inhibitors.

UNIT IV

Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development.

UNIT V

Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth development.

Practical

Understanding dormancy mechanisms in seeds, tubers and bulbs and stratification of seeds, tubers and bulbs, visit to arid, subtropical and temperate horticultural zones to identify growth and development patterns, techniques of growth analysis, evaluation of photosynthetic efficiency under different environments, study of growth regulator functions, hormone assays, understanding ripening phenomenon in fruits and vegetables, study of impact of physical manipulations on growth and development, study of chemical manipulations on growth and development, understanding stress impact on growth and development.

Suggested Readings

- Buchanan B, Gruiessam W & Jones R. 2002. Biochemistry & Molecular Biology of Plants. John Wiley & Sons.
- Epstein E. 1972. Mineral Nutrition of Plants: Principles and Perspectives. Wiley.
- Fosket DE. 1994. Plant Growth and Development: a Molecular Approach. Academic Press.
- Leoplod AC & Kriedermann PE. 1985. Plant Growth and Development. 3rd Ed. Mc Graw-Hill.
- Peter KV. 2008. (Ed.) Basics of Horticulture. New India Publ. Agency.
- Roberts J, Downs S & Parker P. 2002. Plant Growth Development. In: Plants (I. Ridge, Ed.), pp. 221-274, Oxford University Press.
- Salisbury FB & Ross CW. 1992. Plant Physiology. 4th Ed. Wadsworth Publ.

FSC 509 : BIOTECHNOLOGY OF HORTICULTURAL CROPS 2+1

Objective

Understanding the principles, theoretical aspects and developing skills in biotechnology of horticultural crops.

Theory

UNIT I

Harnessing bio-technology in horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture. Contamination control.

UNIT II

Callus culture – types, cell division, growth, differentiation, morphogenesis, organogenesis, embryogenesis.

UNIT III

Use of bioreactors and *in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues, ex vitro, establishment of tissue cultured plants.

UNIT IV

Physiology of hardening - hardening and field transfer, organ culture –meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture and fusion. Construction and identification of somatic hybrids and cybrids

UNIT V

Wide hybridization, *in vitro* pollination and fertilization, haploids, *in vitro*mutation, artificial seeds, cryopreservation, rapid clonal propagation, genetic engineering in horticulture crops, use of molecular markers. *In vitro* selection for biotic and abiotic stress, achievements of biotechnology in horticultural crops.

Practical

An exposure to low cost, commercial and homestead tissue culture laboratories, media preparation, inoculation of explants for clonal propagation, callus induction and culture, regeneration of plantlets from callus, sub-culturing, techniques on anther, ovule, embryo culture, somaclonal variation, *in vitro* mutant selection against abiotic stress, protoplast culture, fusion technique, development of protocols for mass multiplication, project development for establishment of commercial tissue culture laboratory.

Suggested Readings

- Bajaj YPS. (Ed.).1989. Biotechnology in Agriculture and Forestry. Vol. V, Fruits. Springer.
- Brown TA. 2001. Gene Cloning and DNA Analysis and Introduction.Blackwell Publ.
- Chopra VL & Nasim A. 1990. Genetic Engineering and Biotechnology –Concepts, Methods and Applications. Oxford & IBH.
- Gorden H & Rubsell S. 1960. Hormones and Cell Culture. AB Book Publ.
- Keshavachandran R & Peter KV. 2008. Plant Biotechnology: TissueCulture and Gene Transfer.Orient & Longman (Universal Press).
- Keshavachandran R, Nazeem PA, Girija D, John PS & Peter KV. 2007. Recent Trends in Biotechnology of Horticultural Crops. Vols. I, II. New India Publ. Agency.
- Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK & Mohanadas S. 2001. Biotechnology of Horticultural Crops. Vols. I-III. Naya Prokash.
- Pierik RLM. 1987. In vitro Culture of Higher Plants. Martinus Nijhoff Publ.
- Skoog F & Miller CO. 1957. Chemical Regulation of Growth and Formation in Plant Tissue Culture in vitro. Symp. Soc. Exp. Biol. 11: 118-131
- Vasil IK, Vasi M, While DNR & Bery HR.1979. Somatic Hybridizationand Genetic Manipulation in Plants. Plant Regulation and World Agriculture. Planum Press.
- Williamson R. 1981-86. Genetic Engineering. Vols. I-V. Academic Press.

FSC 510 : ORGANIC HORTICULTURE 1+1

Objective

To develop understanding of organic horticulture production system including GAP.

Theory

UNIT I

Organic horticulture – definition, synonyms and misnomers, principles, methods, merits and demerits.

UNIT II

Organic farming systems, components of organic horticultural systems, different organic inputs, their role in organic horticulture, role of biopesticides, biofertilizers, biodynamics and the recent developments.

UNIT III

EM technology and its impact in organic horticulture, indigenous practices of organic farming, sustainable soil fertility management, weed management practices in organic farming, biological/natural control of pests and diseases, organic horticulture in quality improvement.

UNIT IV

GAP - Principles and management, HACCP exercise, certification of organic products and systems, agencies involved at national and international levels, standards evolved by different agencies.

UNIT V

Constraints in certification, organic horticulture and export, IFOAM and global scenario of organic movement, post-harvest management of organic produce.

Practical

Features of organic orchards, working out conversion plan, Input analysismanures, nutrient status assessment of manures, biocomposting, biofertilizers and their application, panchagavya preparation and other organic nutrients application, methods of preparation of compost, vermicompost, green manuring, preparation of neem products and application, BD preparations and their role, EM technology and products, biological/natural control of pests and diseases, soil solarization, frame work for GAP, case studies, HACCP analysis, residue analysis in organic products, documentation for certification, visit to fields cultivated under organic practices.

Suggested Readings

- Claude A, Vandana S, Sultan I, Vijaya L, Korah M & Bernard D. 2000.The Organic Farming Reader. Other Indian Press, Goa.
- Gaur AC, Neblakantan S & Dargan KS. 1984 Organic Manures. ICAR.
- Lampkin N & Ipswich. 1990. Organic Farming. Farming Press. London.
- Lampkin NH & Padel S. 1992. The Economics of Organic Farming - AnInternational Perspective. CABI.
- Palaniappan & Annadurai. 2008. Organic Farming- Theory and Practise. Scientific Publ.
- Peter KV. 2008. (Ed.). Basics of Horticulture. New India Publ. Agency. New Delhi.
- Rao S. 1977. Soil Microorganism *and Plant Growth*. Oxford & IBH.

FSC 511 : PROTECTED FRUIT CULTURE 2+1

Objective

Understanding the principles, theoretical aspects and developing skills in protected cultivation of fruit crops.

Theory

UNIT I

Greenhouse – World scenario, Indian situation: present and future, Different agro-climatic zones in India, Environmental factors and their effects on plant growth.

UNIT II

Basics of greenhouse design, different types of structures – glasshouse, shade net, poly tunnels - Design and development of low cost greenhouse structures.

UNIT III

Interaction of light, temperature, humidity, CO2, water on crop regulation - Greenhouse heating, cooling, ventilation and shading.

UNIT IV

Types of ventilation- Forced cooling techniques - Glazing materials – Micro irrigation and Fertigation.

UNIT V

Automated greenhouses, microcontrollers, waste water recycling, Management of pest and diseases – IPM.

UNIT VI

Media –Types, uses and characteristics.

Practical

Designs of greenhouse, low cost poly tunnels, nethouse- Regulation of light, temperature, humidity in greenhouses, media, greenhouse cooling systems, ventilation systems, fertigation systems, special management practices, project preparation for greenhouses, visit to greenhouses.

Suggested Readings

- Aldrich RA & Bartok JW. 1994. Green House Engineering. NRAES, Riley, Robb Hall, Cornell University, Ithaca, New York.
- Bhatcharjee BS. 1959. Rose Growing in Tropics. Thackarspink & Co. Laurie A, Kiplingr DD & Nelson KS. 1968. Commercial Flower Forcing. McGraw-Hill.
- Mears DR, Kim MK & Roberts WJ. 1971. Structural Analysis at an Experimental Cable-supported Air Inflated Green Houses. Trans. ASAE.
- Pant V Nelson. 1991. Green House Operation and Management. Bali Publ.
- Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2007. Management of Horticultural Crops. Parts I, II. New India Publ. Agency.

FSC 512 : GAP FOR HORTICULTURAL CROPS 1+0

Objective

To impart comprehensive knowledge about the principles and practices of Good Agricultural Practises (GAP) for horticultural crops.

Theory

UNIT I

Genesis of GAP – definition/description, components listed by FAO, frame work.

UNIT II

Management of site history and soil, crop and fodder production, IPM, INM, IWM, irrigation water, crop production and protection. Identification of ways of improving the productivity profitability, and resource efficiency. harvest and post-harvest handling.

UNIT III

Animal production, product certification, animal waste management, animal health and welfare, harvest.

UNIT IV

On farm processing, storage, energy and waste management, human health, welfare, safety, wild life benefits.

UNIT V

Institutions involved in GAP certification. Indian agencies, EUREPGAP (European Retail Producers Group- Good Agricultural Practices), EUREP etc.

Suggested Readings

- Peter KV. 2008. *Basics in Horticulture*. New India Publ. Agency.

FSC 513 : CLIMATE MANAGEMENT IN HORTICULTURAL PRODUCTION 1+0

Objective

To develop understanding about the impact and management of climate in horticultural production.

Theory

UNIT I

Introduction to climate change. Factors directly connected to climate change, average temperature, change in rainfall amount and patterns, rising atmospheric concentrations of CO2, pollution levels such as tropospheric ozone, change in climatic variability and extreme events like receding of glaciers in Himalayas.

UNIT II

Sensors for climate registration and crop monitoring, phytomonitoring and biosensors, plants response to the climate changes, premature bloom, marginally overwintering or inadequate winter chilling hours, insect pests, longer growing seasons and shifts in plant hardiness for perennial fruit crops, flowering plants and other plant species.

UNIT III

Impact of climate changes on invasive insect, disease, weed, pests, horticulture yield, quality and sustainability, climate management in field production – mulching - use of plastic-windbreak- spectral changes- frost protection. Climate management in greenhouse- heating - vents - CO2
injection - screens - artificial light.

UNIT IV

Climate management for control of pests, diseases, quality, elongation of growth and other plant processes- closed production systems around the world. Special protected cultivation now and in the future, growth chambers, production in space, biosphere, future aspects of closed production, future greenhouse, use of LED as artificial light, future sensor types etc. clean development mechanism, role of tropical trees.

Suggested Readings

- Peter KV. 2008. (Ed.). Basics of Horticulture. New India Publ. Agency.
- Rao GSLHV, Rao GGSN, Rao VUM & Ramakrishnan YS. 2008. Climate Change and Agriculture over India. ICAR.
- Rao GSLHV. 2008. *Agricultural Meteorology*. Prentice Hall.

FSC 601 : ADVANCES IN BREEDING OF FRUIT CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of fruit crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

Evolutionary mechanisms, adaptation and domestication, Genetic resources, cytogenetics, cytomorphology, chemotaxonomy, genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits , recent advances in crop improvement efforts- introduction and selection, chimeras, apomixis, clonal selections, intergeneric, interspecific and intervarietal hybridization, mutation and polyploid breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, molecular and transgenic approaches in improvement of selected fruit crops.

Crops

UNIT I : Mango and banana
UNIT II: Papaya, grapes and citrus
UNIT III: Guava and sapota
UNIT IV: Pineapple and avocado
UNIT V: Apple, pear, plums, peaches, apricot, cherries and strawberry

Practical

Description and cataloguing of germplasm, pollen viability tests, pollen germination-isozyme techniques-survey and clonal selection, observations on pest, disease and stress reactions in inbreds and hybrids, use of mutagenes and colchicine for inducing mutation and ploidy changes, practices in different methods of breeding fruit crops and in-vitro breeding techniques.

Suggested Readings

- Bose TK, Mitra SK & Sanyol D. (Ed.). 2002. Fruits of India – Tropical andSub-tropical. 3rd Ed. Vols. I, II. Naya Udyog.
- Chadha KL & Pareek OP. (Eds.). 1996. Advances in Horticulture. Vol. I. Malhotra Publ. House.
- Chadha KL & Shikhamany SD. 1999. The Grape: Improvement, Production and Post-Harvest Management. Malhotra Publ. House.
- Gowen S. 1996. Banana and Plantains. Chapman & Hall.
- Janick J & Moore JN. 1996. Fruit Breeding. Vols.I-III. John Wiley & Sons.
- Nijjar GS. (Ed.). 1977. Fruit Breeding in India. Oxford & IBH.
- Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency.
- Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. Advances in Citriculture. Jagmander Book Agency.
- Stover RH & Simmonds NW. 1991. *Bananas*. Longman.

FSC 602 : ADVANCES IN PRODUCTION OF FRUIT CROPS 2+1

Objective

To keep abreast with latest developments and trends in production technology of fruit crops.

Theory

National and International scenario in fruit production, Recent advances in propagation - root stock influence, planting systems, High density planting, crop modelling, Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Total quality management (TQM) - Current topics.

Crops

UNIT I : Mango and banana
UNIT II: Papaya, grapes and citrus
UNIT III: Guava, sapota and aonla
UNIT IV: Pineapple, avocado and jack
UNIT V: Apple, pear, plums, strawberry, peach, apricot, cherries and nut crops

Practical

Survey of existing fruit cropping systems and development of a model cropping system, Estimating nutrient deficiency- estimation of water use efficiency, soil test-crop response correlations, practices in plant growth regulation, studying physiological and biochemical responses, quality analysis.

Suggested Readings

- Bose TK, Mitra SK & Rathore DS. (Eds.). 1988. Temperate Fruits –Horticulture. Allied Publ.
- Bose TK, Mitra SK & Sanyal D. (Eds.). 2001. Fruits -Tropical and Subtropical. Naya Udyog.
- Bose TK, Mitra SK, Farooqi AA & Sadhu MK. 1999. Tropical Horticulture. Vol. I. Naya Prokash.
- Chadha KL & Pareek OP. (Eds.).1996. Advances in Horticulture. Vols. II, IV. Malhotra Publishing House.
- Chadha KL. 2001. Handbook of Horticulture. ICAR.
- Nakasone HY & Paull RE. 1998. Tropical Fruits. CABI.
- Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

FSC 603 : ADVANCES IN GROWTH REGULATION OF FRUIT CROPS 2+1

Objective

Appraisal on the advances in growth regulation of fruit crops.

Theory

UNIT I

Ecophysiological influences on growth and development of fruit crops flowering, fruit set- Crop load and assimilate partitioning and distribution.

UNIT II

Root and canopy regulation, study of plant growth regulators in fruit culture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants.

UNIT III

Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards.

UNIT IV

Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production.

UNIT V

Flower drop and thinning, fruit set and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, molecular approaches in crop growth regulation- current topics.

Practical

Root- shoot studies, quantifying the physiological and biochemical effects of physical and chemical growth regulation, bioassay and isolation through chromatographic analysis for auxins, gibberellins, experiments on growth regulation during propagation, dormancy, flowering, fruit set and fruit development stages.

Suggested Readings

- Buchanan B, Gruiessam W & Jones R. 2002. Biochemistry & Molecular Biology of Plants. John Wiley & Sons.
- Epstein E. 1972. Mineral Nutrition of Plants: Principles and Perspectives. Wiley.
- Fosket DE. 1994. Plant Growth and Development: A Molecular Approach. Academic Press.
- Leoplod AC & Kriedermann PE. 1985. Plant Growth and Development. 3rd Ed. McGraw-Hill.
- Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency.
- Roberts J, Downs S & Parker P. 2002. Plant Growth Development. In: Plants (I. Ridge, Ed.), pp. 221-274, Oxford University Press.
- Salisbury FB & Ross CW. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.

FSC 604 : GENOMICS AND BIOINFORMATICS IN HORTICULTURE 2+1

Objective

Studies on the fundamentals and application of genomics and bioinformatics in horticulture.

Theory

UNIT I

Primer on bioinformatics and computational genomics, database fundamentals – biological databases, horticultural genome and protein databases, functional genomics.

UNIT II

Dynamic Programming Sequence Alignment, BLAST search engine, FASTA search engine, Microarrays- Microarray Clustering and Classification, Terminologies and Ontologies - EcoCYC knowledge base of E. Coli metabolism - Description of UMLS Semantic Network.

UNIT III

Multiple Sequence Alignment, MSA algorithm descriptions, ClustalW, 1D Motifs, Algorithms and Databases, methods for sequence weighting, BLOCKS database, Making BLOCK motifs, PROSITE database, 3D structure alignment, SCOP, DALI, LOCK, MUSTA algorithm for geometric hashing and multiple alignment.

UNIT IV

Hidden Markov models , Molecular energetics and dynamics , Protein structure prediction, Genetic networks - Modeling and Simulation of Genetic Regulatory Systems- KEGG database of genes and gene pathways/networks - EcoCYC database of metabolic pathways in E. Coli - EGF-signal pathway modeling, Gene finding algorithms – Genome Annotation Assessment Project for Arabidopsis, Comparative genomics algorithms, Genome Alignment.

UNIT V

3D structure computations, NMR, Crytallography, NMR Structure Determination, X-ray Crystallography Structure Determination, Distance Geometry Description, RNA secondary structure, Molecular Modelling and Drug discovery programs.

UNIT VI

Phylogenetic algorithms – Tree base database of phylogenetic information for plants mostly, Tree of Life Page, Samples from the Tree of Life, Ribosomal Database Project, Natural Language Processing , Proteomics, 3D Motifs, Applications and Integration with Horticulture, Final Thoughts.

Practical

Computers, Operating systems and Programming languages, Internet Resources, Horticultural Genome and Protein Databases, BLAST/RNA Structure, Sequence Alignment, Microarray Data Analysis, Ontology, MSA, HMMs, Identification of Functional Sites in Structures, Protein Structure Prediction - Phylogenetics - Gene Finding - Molecular Modelling and Drug Discovery Software – Assignments.

Suggested Readings

- Attwood TK & Parry Smith DJ. 2006. Introduction to Bioinformatics. Pearson Edu.
- Baxevanis AD. 2005. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. 3rd Ed. Wiley.
- Bourne PE & Weissig H. (Eds.). 2004. Structural Bioinformatics. John Wiley & Sons.
- Durbin R, Eddy SR, Krogh A & Mitchison G. 1999. Biological Sequence Analysis: Probabilistic Model of Proteins and Nucleic Acids. Cambridge Univ. Press.

- Keshavachandran R, Nazeem PA, Girija D, John PS & Peter KV. 2007. Recent Trends in Biotechnology of Horticultural Crops. Vols. I, II. New India Publ. Agency.
- Kohane IS, Kho A & Butte AJ. 2002. Microarrays for an Integrative Genomics. M1T Press.
- Mount DW. 2001. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbour Laboratory Press.

FSC 605 : BIOTIC AND ABIOTIC STRESS MANAGEMENT IN HORTICULTURAL CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of biotic andabiotic stress management in horticultural crops.

Theory

UNIT I

Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.).

UNIT II

Pollution - increased level of CO2, industrial wastes, impact of stress in horticultural crop production, stress indices, physiological and biochemical factors associated with stress, horticultural crops suitable for different stress situations.

UNIT III

Crop modeling for stress situations, cropping system, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stress and their impact on crop growth and productivity.

UNIT IV

Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers.

UNIT V

Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, cropping systems, stability and sustainability indices.

Practical

Seed treatment /hardening practices, container seedling production, analysis of soil moisture estimates (FC, ASM, PWP), analysis of plant stress factors, RWC, chlorophyll flurosence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate etc. under varied stress situations, influence of stress on growth and development of seedlings and roots, biological efficiencies, WUE, solar energy conversion and efficiency, crop growth sustainability indices, economics of stress management, visit to orchards and water shed locations.

Suggested Readings

- Blumm A. 1988. Plant Breeding for Stress Environments. CRC.
- Christiansen MN & Lewis CF. 1982. Breeding Plants for Less Favourable Environments. Wiley Inter. Science.
- Gupta US. 1990. Physiological Aspects of Dry Farming.
- Hsiao TC. 1973. Plant Responses to Water Stress. Ann. Rev. Plant Physiology 24: 519-570.
- Kramer PJ. 1980. Drought Stress and the Origin of Adaptation. In: Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons.
- Levitt J. 1972. Response of Plants to Environmental Stresses. Academic Press.
- Maloo SR. 2003. Abiotic Stress and Crop Productivity. Agrotech Publ. Academy.
- Mussell H & Staples R. 1979. Stress Physiology in Crop Plants. Wiley Inter. Science.
- Nickell LG. 1983. Plant Growth Regulating Chemicals. CRC.
- Peter KV. (Ed.). 2008. Basics of Horticulture. New India Publ. Agency.
- Turener NC & Kramer PJ. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons.

FSC606 : SYSTEMATICS OF FRUITS CROPS 2+1

Theory

Systematic pomology – definition and importance, systems of classification and nomenclature; classification of tropical, subtropical fruits and plantation crops; botanical description of families, genera and species and pomological description of varieties.

Practical :

Preparation and use of keys for identifying varieties and species of fruit and plantation crops, pomological description important commercial varieties in different fruits and plantation crops.

Suggested Readings

- Baily LH. Manual of Cultivated Plants
- Chopra GL. 1968. Angiosperms - Systematics and Life Cycle. S. Nagin
- Dutta AC. 1986. A Class Book of Botany. Oxford Univ. Press.
- Heywood VH. Flowering Plants of the World.
- Heywood VH Modern method in Plant taxonomy.
- Pandey BP. 1999. Taxonomy of Angiosperm. S. Chand & Co.
- Soule J. 1985. Glossary for Horticultural Crops. John Wiley & Sons.
- Srivastava U, Mahajan RK, Gangopadyay KK, Singh M & Dhillon BS. 2001. Minimal Descriptors of Agri-Horticultural Crops. Part-II: Vegetable Crops. NBPGR, New Delhi.
- Vasistha. 1998. Taxonomy of Angiosperm. Kalyani.
- Zeilinski, QB. Modern Systemic Pomology, Westport, Connecticut.

VEGETABLE SCIENCE

VSC 501 : PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS 2+1

Objective

To educate production technology of cool season vegetables.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production of:

UNIT I Potato
UNIT II Cole crops: cabbage, cauliflower, knoll kohl, sprouting broccoli, Brussels sprout
UNIT III Root crops: carrot, radish, turnip and beetroot
UNIT IV Bulb crops: onion and garlic
UNIT V Peas and broad bean, green leafy cool season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of winter vegetable crops and their economics; Experiments to demonstrate the role of mineral elements, plant growth substances and herbicides; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial greenhouse/ polyhouse.

Suggested Readings

- Bose TK & Som MG. (Eds.). 1986. Vegetable Crops in India. Naya Prokash.
- Bose TK, Som MG & Kabir J. (Eds.). 2002. Vegetable Crops. Naya Prokash.
- Bose TK, Som MG & Kabir J. (Eds.). 1993. Vegetable Crops. Naya Prokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. Vegetable Crops. Vols. I-III. Naya Udyog.

- Chadha KL & Kalloo G. (Eds.). 1993-94. Advances in Horticulture Vols. V-X. Malhotra Publ. House.
- Chadha KL. (Ed.). 2002. Hand Book of Horticulture. ICAR.
- Chauhan DVS. (Ed.). 1986. Vegetable Production in India. Ram Prasad & Sons.
- Decoteau DR. 2000. Vegetable Crops. Prentice Hall.
- Edmond JB, Musser AM & Andrews FS. 1951. Fundamentals of Horticulture. Blakiston Co.
- Fageria MS, Choudhary BR & Dhaka RS. 2000. Vegetable Crops: Production Technology. Vol. II. Kalyani.
- Gopalakrishanan TR. 2007. Vegetable Crops. New India Publ. Agency.
- Hazra P & Som MG. (Eds.). 1999. Technology for Vegetable Productionand Improvement. Naya Prokash.
- Rana MK. 2008. Olericulture in India. Kalyani Publ.
- Rana MK. 2008. Scientific Cultivation of Vegetables. Kalyani Publ.
- Rubatzky VE & Yamaguchi M. (Eds.). 1997. World Vegetables:Principles, Production and Nutritive Values. Chapman & Hall.
- Saini GS. 2001. A Text Book of Oleri and Flori Culture. Aman Publ. House.
- Salunkhe DK & Kadam SS. (Ed.). 1998. Hand Book of Vegetable Scienceand Technology: Production, Composition, Storage and Processing. Marcel Dekker.
- Shanmugavelu KG. 1989. Production Technology of Vegetable Crops. Oxford & IBH.
- Singh DK. 2007. Modern Vegetable Varieties and Production Technology. International Book Distributing Co.
- Singh SP. (Ed.). 1989. Production Technology of Vegetable Crops. Agril. Comm. Res. Centre.
- Thamburaj S & Singh N. (Eds.). 2004. Vegetables, Tuber Crops and Spices. ICAR.
- Thompson HC & Kelly WC. (Eds.). 1978. *Vegetable Crops*. Tata McGraw-Hill.

VSC 502 : PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS 2+1

Objective

To teach production technology of warm season vegetables.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures, economics of crop production and seed production of:

UNIT I

Tomato, eggplant, hot and sweet peppers

UNIT II

Okra, beans and cowpea

UNIT III

Cucurbitaceous crops

UNIT IV

Tapioca and sweet potato

UNIT V

Green leafy warm season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of summer vegetable crops and their economics; study of physiological disorders and deficiency of mineral elements, preparation of cropping schemes for commercial farms; experiments to demonstrate the role of mineral elements, physiological disorders; plant growth substances and herbicides; seed extraction techniques; identification of important pests and diseases and their control; maturity standards; economics of warm season vegetable crops.

Suggested Readings

- Bose TK & Som MG. (Eds.). 1986. Vegetable Crops in India. Naya Prokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. Vegetable Crops. Vols. I-III. Naya Udyog.
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- Pandey AK & Mudranalay V. (Eds.). Vegetable Production in India: Important Varieties and Development Techniques.
- Rana MK. 2008. Olericulture in India. Kalyani.
- Rana MK. 2008. Scientific Cultivation of Vegetables. Kalyani.
- Rubatzky VE & Yamaguchi M. (Eds.). 1997. World Vegetables:Principles, Production and Nutritive Values. Chapman & Hall.
- Saini GS. 2001. A Text Book of Oleri and Flori Culture. Aman Publ. House.
- Salunkhe DK & Kadam SS. (Ed.). 1998. Hand Book of Vegetable Science and Technology: Production, Composition, Storage and Processing. Marcel Dekker.
- Shanmugavelu KG. 1989. Production Technology of Vegetable Crops. Oxford & IBH.
- Singh DK. 2007. Modern Vegetable Varieties and Production Technology. International Book Distributing Co.
- Singh NP, Bharadwaj AK, Kumar A & Singh KM. 2004. Modern Technology on Vegetable Production. International Book Distributing Co.
- Singh SP. (Ed.). 1989. Production Technology of Vegetable Crops. Agril. Comm. Res. Centre.
- Thamburaj S & Singh N. 2004. Vegetables, Tuber Crops and Spices. ICAR.
- Thompson HC & Kelly WC. (Eds.). 1978. *Vegetable Crops*. Tata Mc Graw Hill.

VSC 503 : BREEDING OF VEGETABLE CROPS 2+1

Objective

To educate principles and practices adopted for breeding of vegetable crops.

Theory

Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, molecular marker, genomics, marker assisted breeding and QTLs, biotechnology and their use in breeding in vegetable crops-Issue of patenting, PPVFR act.

UNIT I

Potato and tomato

UNIT II

Eggplant, hot pepper, sweet pepper and okra

UNIT III

Peas and beans, amaranth, chenopods and lettuce

UNIT IV

Gourds, melons, pumpkins and squashes

UNIT V

Cabbage, cauliflower, carrot, beetroot, radish, sweet potato and tapioca

Practical

Selection of desirable plants from breeding population observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations; induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops; hybrid seed production of vegetable crops in bulk. screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops, demonstration of sib-mating and mixed population; molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques. Visit to breeding blocks.

Suggested Readings

- Allard RW. 1999. Principles of Plant Breeding. John Wiley & Sons.
- Basset MJ. (Ed.). 1986. Breeding Vegetable Crops. AVI Publ.
- Dhillon BS, Tyagi RK, Saxena S. & Randhawa GJ. 2005. Plant Genetic Resources: Horticultural Crops. Narosa Publ. House.
- Fageria MS, Arya PS & Choudhary AK. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani.
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- Hayes HK, Immer FR & Smith DC. 1955. Methods of Plant Breeding. McGraw-Hill.
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- Kumar JC & Dhaliwal MS. 1990. Techniques of Developing Hybrids in Vegetable Crops. Agro Botanical Publ.
- Paroda RS & Kalloo G. (Eds.). 1995. Vegetable Research with Special Reference to Hybrid Technology in Asia-Pacific Region. FAO.
- Peter KV & Pradeepkumar T. 2008. Genetics and Breeding of Vegetables. Revised, ICAR.
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- Ram HH. 1998. Vegetable Breeding: Principles and Practices. Kalyani.
- Simmonds NW. 1978. Principles of Crop Improvement. Longman.
- Singh BD. 1983. Plant Breeding. Kalyani.
- Singh PK, Dasgupta SK & Tripathi SK. 2004. Hybrid Vegetable Development. International Book Distributing Co.
- Swarup V. 1976. *Breeding Procedure for Cross-pollinated Vegetable Crops*. ICAR.

VSC 504 : GROWTH AND DEVELOPMENT OF VEGETABLE CROPS 2+1

Objective

To teach the physiology of growth and development of vegetable crops.

Theory

UNIT I

Cellular structures and their functions; definition of growth and development, growth analysis and its importance in vegetable production.

UNIT II

Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellilns, cyktokinins and abscissic acid; Application of synthetic hormones, plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production.

UNIT III

Role of light, temperature and photoperiod on growth, development of underground parts, flowering and sex expression in vegetable crops; apical dominance.

UNIT IV

Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening.

UNIT V

Plant growth regulators in relation to vegetable production; morphogenesis and tissue culture techniques in vegetable crops.

Practical

Preparation of solutions of plant growth substances and their application; experiments in breaking and induction of dormancy by chemicals; induction of parthenocarpy and fruit ripening; application of plant growth substances for improving flower initiation, changing sex expression in cucurbits and checking flower and fruit drops and improving fruit set in solanaceous vegetables; growth analysis techniques in vegetable crops.

Suggested Readings

- Bleasdale JKA. 1984. Plant Physiology in Relation to Horticulture. 2nd Ed. MacMillan.
- Gupta US. (Ed.). 1978. Crop Physiology. Oxford & IBH.
- Krishnamoorti HN. 1981. Application Plant Growth Substances and Their Uses in Agriculture. Tata-McGraw Hill.
- Peter KV. (Ed.). 2008. Basics of Horticulture. New India Publ. Agency.
- Saini RS, Sharma KD, Dhankhar OP & Kaushik RA. (Eds.). 2001. Laboratory Manual of Analytical Techniques in Horticulture. Agrobios.
- Wien HC. (Ed.). 1997. *The Physiology of Vegetable Crops*. CABI.

VSC 505 : SEED PRODUCTION TECHNOLOGY OF VEGETABLE CROPS 2+1

Objective

To educate principles and methods of quality seed and planting material production in vegetable crops.

Theory

UNIT I

Definition of seed and its quality, new seed policies; DUS test, scope of vegetable seed industry in India.

UNIT II

Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behaviour, seed development and maturation; methods of hybrid seed production.

UNIT III

Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control.

UNIT VI

Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/packets), storage and cryopreservation of seeds, synthetic seed technology.

UNIT V

Agro-techniques for seed production in solanaceous vegetables, cucurbits, leguminous vegetables, cole crops, bulb crops, leafy vegetables, okra, vegetatively propagated vegetables.

Practical

Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, physical purity) and seed health testing; testing, releasing and notification procedures of varieties; floral biology; rouging of off-type; methods of hybrid seed production in important vegetable and spice crops; seed extraction techniques; handling of seed processing and seed testing equipments; seed sampling; testing of vegetable seeds for seed purity, germination, vigour and health; visit to seed processing units, seed testing laboratory and seed production farms.

Suggested Readings

- Agrawal PK & Dadlani M. (Eds.). 1992. Techniques in Seed Science and Technology. South Asian Publ.
- Agrawal RL. (Ed.). 1997. Seed Technology. Oxford & IBH.
- Bendell PE. (Ed.). 1998. Seed Science and Technology: Indian Forestry Species. Allied Publ.
- Fageria MS, Arya PS & Choudhary AK. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani.
- George RAT. 1999. Vegetable Seed Production. 2nd Ed. CABI.

- Kumar JC & Dhaliwal MS. 1990. Techniques of Developing Hybrids in Vegetable Crops. Agro Botanical Publ.
- More TA, Kale PB & Khule BW. 1996. Vegetable Seed production Technology. Maharashtra State Seed Corp.
- Rajan S & Baby L Markose. 2007. Propagation of Horticultural Crops. New India Publ. Agency.
- Singh NP, Singh DK, Singh YK & Kumar V. 2006. Vegetable Seed Production Technology. International Book Distributing Co.
- Singh SP. 2001. *Seed Production of Commercial Vegetables*. Agrotech Publ. Academy.

VSC 506 : SYSTEMATICS OF VEGETABLE CROPS 1+1

Objective

To teach morphological, cytological and molecular taxonomy of vegetable crops.

Theory

UNIT I

Principles of classification; different methods of classification; salient features of international code of nomenclature of vegetable crops.

UNIT II

Origin, history, evolution and distribution of vegetable crops, botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables.

UNIT III

Cytological level of various vegetable crops; descriptive keys for important vegetables.

UNIT IV

Importance of molecular markers in evolution of vegetable crops; molecular markers as an aid in characterization and taxonomy of vegetable crops.

Practical

Identification, description, classification and maintenance of vegetable species and varieties; survey, collection of allied species and genera locally available; preparation of keys to the species and varieties; methods of preparation of herbarium and specimens.

Suggested Readings

- Chopra GL. 1968. Angiosperms - Systematics and Life Cycle. S. Nagin
- Dutta AC. 1986. A Class Book of Botany. Oxford Univ. Press.
- Pandey BP. 1999. Taxonomy of Angiosperm. S. Chand & Co.
- Peter KV & Pradeepkumar T. 2008. Genetics and Breeding of Vegetables. (Revised), ICAR.
- Soule J. 1985. Glossary for Horticultural Crops. John Wiley & Sons.
- Srivastava U, Mahajan RK, Gangopadyay KK, Singh M & Dhillon BS. 2001. Minimal Descriptors of Agri-Horticultural Crops. Part-II: Vegetable Crops. NBPGR, New Delhi.
- Vasistha. 1998. Taxonomy of Angiosperm. Kalyani.
- Vincent ER & Yamaguchi M. 1997. *World Vegetables*. 2nd Ed. Chapman & Hall.

VSC 507 : PRODUCTION TECHNOLOGY OF UNDEREXPLOITED VEGETABLE CROPS 1+1

Objective

To educate production technology of underutilized vegetable crops.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed production of:

UNIT I

Asparagus, artichoke and leek

UNIT II

Brussels's sprout, Chinese cabbage, broccoli, kale and artichoke.

UNIT III

Amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathu (chenopods) and chekurmanis.

UNIT IV

Elephant foot yam, lima bean, winged bean, vegetable pigeon pea, jack bean and sword bean.

UNIT V

Sweet gourd, spine gourd, pointed gourd, Oriental pickling melon and little gourd (kundru).

Practical

Identification of seeds; botanical description of plants; layout and planting; cultural practices; short-term experiments of underexploited vegetables.

Suggested Readings

- Bhat KL. 2001. Minor Vegetables - Untapped Potential. Kalyani.
- Indira P & Peter KV. 1984. Unexploited Tropical Vegetables. Kerala Agricultural University, Kerala.
- Peter KV. (Ed.). 2007-08. Underutilized and Underexploited Horticultural Crops. Vols. I-IV. New India Publ. Agency.
- Rubatzky VE & Yamaguchi M. (Eds.). 1997. World Vegetables: Principles, Production and Nutritive Values. Chapman & Hall
- Srivastava U, Mahajan RK, Gangopadyay KK, Singh M & Dhillon BS. 2001. Minimal Descriptors of *Agri-Horticultural Crops*. Part-II: *Vegetable Crops*. NBPGR, New Delhi.

VSC 508 : VEGETABLE CROPS ORGANIC VEGETABLE PRODUCTION TECHNOLOGY 1+1

Objective

To educate principles, concepts and production of organic farming in vegetable crops.

Theory

UNIT I

Importance, principles, perspective, concept and component of organic production of vegetable crops.

UNIT II

Organic production of vegetables crops, *viz.,* solanaceous crops, cucurbits, cole crops, root and tuber crops.

UNIT III

Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.

UNIT IV

Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, Panchagavvya, Biodynamics, preparation etc Pest and disease management in organic farming; ITK's in organic farming. Role of botanicals and bio-control agents.

UNIT V

GAP and GMP- Certification of organic products; organic production and export - opportunity and challenges.

Practical

Method of preparation of compost, vermicomposting, biofertilizers, soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, water management, organic soil amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Readings

- Dahama AK. 2005. Organic Farming for Sustainable Agriculture. 2nd Ed. Agrobios.
- Gehlot G. 2005. Organic Farming; Standards, Accreditation Certification and Inspection. Agrobios.
- Palaniappan SP & Annadorai K. 2003. Organic Farming, Theory and Practice. Scientific Publ.
- Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. Management of Horticultural Crops. New India Publ. Agency.

❖ Shivashankar K. 1997. Food Security in Harmony with Nature. 3rd IFOAMASIA, Scientific Conf.. 1- 4 December, 1997, UAS, Bangalore.

VSC 509 : FUNDAMENTALS OF PROCESSING OF VEGETABLES 2+1

Objective

To educate principles and practices of processing of vegetable crops.

Theory

UNIT I

History of food preservation. Present status and future prospects of vegetable preservation industry in India.

UNIT II

Spoilage of fresh and processed horticultural produce; biochemical changes and enzymes associated with spoilage of horticultural produce; principal spoilage organisms, food poisoning and their control measures. Role of microorganisms in food preservation.

UNIT III

Raw materials for processing. Primary and minimal processing; processing equipments; Layout and establishment of processing industry, FPO licence. Importance of hygiene; Plant sanitation.

UNIT IV

Quality assurance and quality control, TQM, GMP. Food standards – FPO, PFA, etc. Food laws and regulations.

UNIT V

Food safety – Hazard analysis and critical control points (HACCP). Labeling and labeling act, nutrition labeling.

UNIT VI

Major value added products from vegetables.Utilization of byproducts of vegetable processing industry; Management of waste from processing factory.

UNIT VII

Investment analysis. Principles and methods of sensory evaluation of fresh and processed vegetables.

Practical

Study of machinery and equipments used in processing of horticultural produce; Chemical analysis for nutritive value of fresh and processed vegetables; Study of different types of spoilages in fresh as well as processed horticultural produce; Classification and identification of spoilage organisms; Study of biochemical changes and enzymes associated with spoilage; Laboratory examination of vegetable products; Sensory evaluation of fresh and processed vegetables; Study of food standards – National, international, CODEX Alimentarius; Visit to processing units to study the layout, equipments, hygiene, sanitation and residual / waste management.

Suggested Readings

❖ Arthey D & Dennis C. 1996. Vegetable Processing. Blackie/Springer- Verlag.
❖ Chadha DS. 2006. The Prevention of Food Adulteration Act. Confed. Of Indian Industry.
❖ Desrosier NW. 1977. Elements and Technology. AVI Publ. Co. FAO. 1997. Fruit and Vegetable Processing. FAO.
❖ FAO. CODEX Alimentarius: Joint FAO/WHO Food Standards Programme. 2nd Ed. Vol. VB. Tropical Fresh Fruits and Vegetables. FAO.
❖ FAO. Food Quality and Safety Systems – Training Manual on Food Hygiene and HACCP. FAO.
❖ Fellow's P. 1988. Food Processing Technology. Ellis Horwood International.
❖ Frazier WC & Westhoff DC. 1995. Food Microbiology. 4th Ed. Tata McGraw Hill.
❖ Giridharilal GS, Siddappa & Tandon GL. 1986. Preservation of Fruits and Vegetables. ICAR.
❖ Gisela J. 1985. Sensory Evaluation of Food – Theory and Practices. Ellis Horwood.
❖ Graham HD. 1980. Safety of Foods. AVI Publ. Co.
❖ Hildegrade H & Lawless HT. 1997. Sensory Evaluation of Food. CBS.
❖ Joslyn M & Heid. Food Processing Operations. AVI Publ. Co.
❖ Mahindru SN. 2004. Food Safety: Concepts and Reality. APH Publ. Corp.

- Ranganna S. 1986. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw Hill.
- Shapiro R. 1995. Nutrition Labeling Handbook. Marcel Dekker.
- Srivastava RP & Kumar S. 2003. Fruit and Vegetable Preservation: Principles and Practices. 3rd Ed. International Book Distri. Co.
- Tressler & Joslyn MA. 1971. Fruit and Vegetable Juice Processing Technology. AVI Publ. Co.
- Verma LR & Joshi VK. 2000. Post-harvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation *and Waste Management*. Indus Publ. Co.

VSC 601 : ADVANCES IN VEGETABLE PRODUCTION 2+1

Objective

To keep abreast with latest developments and trends in production technology of vegetable crops.

Theory

Present status and prospects of vegetable cultivation; nutritional and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies, disorders and correction methods; different cropping systems; mulching; containerized culture for year round vegetable production; low cost polyhouse; net house production; crop modeling, organic gardening; vegetable production for pigments, export and processing of:

UNIT I

Tomato, brinjal, chilli, sweet pepper and potato

UNIT II

Cucurbits, cabbage, cauliflower and knol-khol

UNIT III

Bhendi, onion, peas and beans, amaranthus and drumstick

UNIT IV

Carrot, beet root and radish

UNIT V

Sweet potato, tapioca, elephant foot yam and taro

Practical

Seed hardening treatments; practices in indeterminate and determinate vegetable growing and organic gardening; portrays and ball culture; diagnosis of nutritional and physiological disorders; analysis of physiological factors like anatomy; photosynthesis; light intensity in different cropping situation; assessing nutrient status, use of plant growth regulators; practices in herbicide application; estimating water requirements in relation to crop growth stages, maturity indices; dryland techniques for rainfed vegetable production; production constraints; analysis of different cropping system in various situation like cold and hot set; vegetable waste recycling management; quality analysis ;marketing survey of the above crops; visit to vegetable and fruit mals and packing houses.

Suggested Readings

- Bose TK & Som NG. 1986. Vegetable Crops of India. Naya Prokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. Vegetable Crops. Vols. I-III. Naya Udyog.
- Brewster JL. 1994. Onions and other Vegetable Alliums. CABI.
- FFTC. Improved Vegetable Production in Asia. Book Series No. 36.
- Ghosh SP, Ramanujam T, Jos JS, Moorthy SN & Nair RG. 1988. Tuber Crops. Oxford & IBH.
- Gopalakrishnan TR. 2007. Vegetable Crops. New India Publishing Agency.
- Kallo G & Singh K. (Ed.). 2001. Emerging Scenario in Vegetable Research and Development. Research Periodicals & Book Publ. House.
- Kurup GT, Palanisami MS, Potty VP, Padmaja G, Kabeerathuma S & Pallai SV. 1996. Tropical Tuber Crops, Problems, Prospects and Future Strategies. Oxford & IBH.

- Sin MT & Onwueme IC. 1978. The Tropical Tuber Crops. John Wiley & Sons.
- Singh NP, Bhardwaj AK, Kumar A & Singh KM. 2004. Modern Technology on Vegetable Production. International Book Distr. Co.
- Singh PK, Dasgupta SK & Tripathi SK. 2006. Hybrid Vegetable Development. International Book Distr. Co.

VSC 602 : ADVANCES IN BREEDING OF VEGETABLE CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of vegetable crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

Evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, *in vitro* breeding; breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance of:

UNIT I

Tomato, brinjal, chilli, sweet pepper and potato

UNIT II

Cucurbits, Cabbage, cauliflower and knol-khol

UNIT III

Bhindi/okra, onion, peas and beans, amaranthus and drumstick

UNIT IV

Carrot, beet root and radish

UNIT V

Sweet potato, tapioca, elephant foot yam and taro

Practical

Designing of breeding experiments, screening techniques for abiotic stresses, screening and rating for pest, disease and nematode resistance, estimation of quality and processing characters, screening for-quality improvement, estimation of heterosis and combining ability, induction and identification of mutants and polyploids, distant hybridization and embryo rescue techniques.

Suggested Readings

- Acta Horticulture. Conference on Recent Advance in Vegetable Crops. Vol. 127.
- Chadha KL, Ravindran PN & Sahijram L. 2000. Biotechnology in Horticultural and Plantation Crops. Malhotra Publ. House.
- Chadha KL. 2001. Hand Book of Horticulture. ICAR.
- Dhillon BS, Tyagi RK, Saxena S & Randhawa GJ. 2005. Plant Genetic Resources: Horticultural Crops. Narosa Publ. House.
- Janick JJ. 1986. Horticultural Science. 4th Ed. WH Freeman & Co.
- Kaloo G & Singh K. 2001. Emerging Scenario in Vegetable Research and Development. Research Periodicals and Book Publ. House.
- Kaloo G. 1994. Vegetable Breeding. Vols. I-III. Vedams eBooks.
- Peter KV & Pradeep Kumar T. 2008. Genetics and Breeding of Vegetables. (Revised Ed.). ICAR.
- Ram HH. 2001. *Vegetable Breeding*. Kalyani.

VSC 603 : PROTECTED CULTIVATION OF VEGETABLE CROPS 1+1

Objective

To impart latest knowledge in growing of vegetable crops under protected environmental condition.

Theory

Crops: Tomato, capsicum, cucumber, melons and lettuce

UNIT I

Importance and scope of protected cultivation of vegetable crops; principles used in protected cultivation, energy management, low cost structures; training methods; engineering aspects.

UNIT II

Regulatory structures used in protected structures; types of greenhouse/polyhouse/nethouse, hot beds, cold frames, effect of environmental factors, *viz.* temperature, light, CO2 and humidity on growth of different vegetables, manipulation of CO2, light and temperature for vegetable production, fertigation.

UNIT III

Nursery raising in protected structures like poly-tunnels, types of benches and containers, different media for growing nursery under cover.

UNIT IV

Regulation of flowering and fruiting in vegetable crops, technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, training and staking in protected crops, varieties and hybrids for growing vegetables in protected structures.

UNIT V

Problem of growing vegetables in protected structures and their remedies, insect and disease management in protected structures; soil-less culture, use of protected structures for seed production.

Practical

Study of various types of structures, methods to control temperature, CO2 light, media, training and pruning, maintenance of parental lines and hybrid seed production of vegetables, fertigation and nutrient management, control of insect-pests and disease in greenhouse; economics of protected cultivation, visit to established green/polyhouse/net house/shade house in the region.

Suggested Readings

- Anonymous 2003. Proc. All India Seminar on Potential and Prospects for Protective Cultivation. Organised by Institute of Engineers, Ahmednagar. Dec.12-13, 2003.
- Chandra S & SomV. 2000. Cultivating Vegetables in Green House. Indian Horticulture 45:17-18.
- Prasad S & Kumar U. 2005. Greenhouse Management for Horticultural Crops. 2nd Ed. Agrobios.
- Tiwari GN. 2003. Green House Technology for Controlled Environment.
- Narosa Publ. House.

VSC 604 : BIOTECHNOLOGY IN VEGETABLE CROPS 2+1

Objective

To teach advances in biotechnology for improvement of vegetable crops.

Theory

Crops: Tomato, eggplant, hot and sweet pepper, potato, cabbage, cauliflower, tapioca, onion, cucurbits.

UNIT I

In vitro culture methods and molecular approaches for crop improvement in vegetables, production of haploids, disease elimination in horticultural crops, micro grafting, somoclones and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, *in vitro*production of secondary metabolites.

UNIT II

Protoplast culture and fusion; construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in vitro* conservation.

UNIT III

In vitro mutation for biotic and abiotic stresses, recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology.

UNIT IV

Quality improvement, improvement for biotic and abiotic stresses, transgenic plants.

UNIT V

Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements, problems and future thrusts in horticultural biotechnology.

Practical

Establishment of axenic explants, callus initiation and multiplication, production of suspension culture, cell and protoplast culture, fusion, regeneration and identification of somatic hybrids and cybrids; Identification of embryonic and non-embryonic calli, development of cell lines; *in vitro* mutant selection for biotic and abiotic stresses, *In vitro* production and characterization of secondary metabolites, isolated microspore culture, isolation and amplification of DNA, gene transfer methods, molecular characterization of transgenic plants.

Suggested Readings

- Bajaj YPS. (Ed.). 1987. Biotechnology in Agriculture and Forestry. Vol.XIX. Hitech and Micropropagation. Springer.
- Chadha KL, Ravindran PN & Sahijram L. (Eds.). 2000. Biotechnology of Horticulture and Plantation Crops. Malhotra Publ. House.
- Debnath M. 2005. Tools and Techniques of Biotechnology. Pointer Publ.
- Glover MD. 1984. Gene Cloning: The Mechanics of DNA Manipulation. Chapman & Hall.
- Gorden H & Rubsell S. 1960. Hormones and Cell Culture. AB Book Publ.
- Keshavachandran R & Peter KV. 2008. Plant Biotechnology: Tissue Culture and Gene Transfer. Orient & Longman (Universal Press).
- Keshavachandran R et al. 2007. Recent Trends in Biotechnology of Horticultural Crops. New India Publ. Agency.
- Panopoulas NJ. (Ed.). 1981. Genetic Engineering in Plant Sciences. Praeger Publ.
- Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK & Mohanadas S. 2001. Biotechnology of Horticultural Crops. Vols. I-III. Naya Prokash.
- Pierik RLM. 1987. In vitro Culture of Higher Plants. Martinus Nijhoff Publ.
- Prasad S. 1999. Impact of Plant Biotechnology on Horticulture. 2nd Ed. Agro Botanica.
- Sharma R. 2000. Plant Tissue Culture. Campus Books.
- Singh BD.2001. Biotechnology. Kalyani.
- Skoog Y & Miller CO. 1957. Chemical Regulation of Growth and Formation in Plant Tissue Cultured in vitro. Attidel. II Symp. On Biotechnology Action of Growth Substance.
- Vasil TK, Vasi M, While DNR & Bery HR. 1979. Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture. Planum Press.
- Williamson R. 1981-86. *Genetic Engineering*. Vols. I-V.

VSC 605 : SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE CROPS 2+1

Objective

To educate the recent trends in the certification, processing and storage of vegetable crops.

Theory

UNIT I

Seed certification, objectives, organization of seed certification, minimum seed certification standards of vegetable crops, field inspection, specification for certification.

UNIT II

Seed processing, study of seed processing equipments seed cleaning and upgrading, Seed packing and handling, equipment used for packaging of seeds, procedures for allocating lot number.

UNIT III

Pre-conditioning, seed treatment, benefits, types and products, general principles of seed storage, advances in methods of storage, quality control in storage, storage containers, seed longevity and deterioration, sanitation, temperature and relative humidity control.

UNIT IV

Seed testing; ISTA rules for testing, moisture, purity germination, vigor test, seed sampling, determination of genuineness of varieties, seed viability, seed health testing; seed dormancy and types of dormancy, factors responsible for dormancy.

UNIT V

Seed marketing, demand forecast, marketing organization, economics of seed production; farmers' rights, seed law enforcement, seed act and seed policy.

Practical

Seed sampling, purity, moisture testing, seed viability, seed vigor tests, seed health testing, seed cleaning, grading and packaging; handling of seed testing equipment and processing machines; seed treatment methods, seed priming and pelleting; field and seed inspection, practices in rouging, seed storage, isolation distances, biochemical tests, visit to seed testing laboratories and processing plants, mixing and dividing instruments, visit to seed processing unit and warehouse visit and know about sanitation standards.

Suggested Readings

- Agrawal PK & Dadlani M. 1992. Tecniques in Seed Science and Technology. South Asian Publ.
- Singh N, Singh DK, Singh YK & Kumar V. 2006. Vegetable Seed Production Technology. International Book Distr. Co.
- Singh SP. 2001. Seed Production of Commercial Vegetables. Agrotech Publ. Academy.
- Tanwar NS & Singh SV. 1988. Indian Minimum Seed Certification Standards. Central Seed Certification Board, GOI, New Delhi.
- Rajan S & Baby L Markose 2007. Propagation of Horticultural Crops. New India Publ. Agency.

VSC 606 : ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of vegetable crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

UNIT I

Environmental stress and its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress; root stock, use of wild species, use of antitranspirants.

UNIT II

Mechanism and measurements of tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

UNIT III

Soil-plant-water relations under different stress conditions in vegetable crops production and their management practices.

UNIT IV

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

UNIT V

Techniques of vegetable growing under high and low temperature conditions, use of chemicals in alleviation of different stresses.

Practical

Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops, measurement of tolerance to various stresses in vegetable crops, short term experiments on growing vegetable under water deficit, water-logging, salinity and sodicity, high and low temperature conditions, and use of chemicals for alleviation of different stresses.

Suggested Readings

- Dwivedi P & Dwivedi RS. 2005. Physiology of Abiotic stress in Plants. Agrobios.
- Lerner HR (Ed.). 1999. Plant Responses to Environmental Stresses. Marcel Decker.
- Maloo SR. 2003. Abiotic Stresses and Crop Productivity. Agrotech Publ. Academy.

FLORICULTURE AND LANDSCAPE ARCHITECTURE

FLA 501 : BREEDING OF FLOWER CROPS AND ORNAMENTAL PLANTS 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of flower crops and ornamental plants.

Theory

UNIT I

Principles -- Evolution of varieties, origin, distribution, genetic resources, genetic divergence- Patents and Plant Variety Protection in India.

UNIT II

Genetic inheritance -- of flower colour, doubleness, flower size, fragrance, post harvest life.

UNIT III

Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants-- introduction, selection, domestication, polyploid and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops.

UNIT IV

Breeding constraints and achievements made in commercial flowers - rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster, heliconia, liliums, nerium, gaillardia.

UNIT V

Breeding constraints and achievements made in ornamental plants – petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snapdragon, pansy) and ornamental foliages– Introduction and selection of plants for waterscaping and xeroscaping.

Practical

Description of botanical features– Cataloguing of cultivars, varieties and species in flowers, floral biology, selfing and crossing, evaluation of hybrid progenies, seed production-Induction of mutants through physical and chemical mutagens, induction of polyploidy, screening of plants for biotic, abiotic stresses and environmental pollution, *in vitro* breeding in flower crops and ornamental plants.

Suggested Readings

- Bhattacharjee SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
- Bose TK & Yadav LP. 1989. Commercial Flowers. Naya Prokash.
- Chadha KL & Choudhury B.1992. Ornamental Horticulture in India. ICAR.
- Chadha KL. 1995. Advances in Horticulture. Vol. XII. Malhotra Publ. House.
- Chaudhary RC. 1993. Introduction to Plant Breeding. Oxford & IBH.
- Singh BD. 1990. Plant Breeding. Kalyani.

FLA 502 : PRODUCTION TECHNOLOGY OF CUT FLOWERS 2+1

Objective

To impart basic knowledge about the importance and production technology of cut flowers grown in India.

Theory

UNIT I

Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India- Patent rights, nursery management, media for nursery, special nursery practices.

UNIT II

Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO2 on growth and flowering.

UNIT III

Flower production – water and nutrient management, fertigation, weed management, rationing, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes.

UNIT IV

Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation.

UNIT V

Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Pre-cooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, Agri Export Zones.

Crops:

Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, liliums, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliages and fillers.

Practical

Botanical description of varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, cold chain, project preparation for regionally important cut flowers, visit to commercial cut flower units and case study.

Suggested Readings

- Arora JS. 2006. Introductory Ornamental horticulture. Kalyani.
- Bhattacharjee SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
- Bose TK & Yadav LP. 1989. Commercial Flowers. Naya Prokash.
- Bose TK, Maiti RG, Dhua RS & Das P. 1999. Floriculture and Landscaping. Naya Prokash.
- Chadha KL & Chaudhury B. 1992. Ornamental Horticulture in India. ICAR.
- Chadha KL. 1995. Advances in Horticulture. Vol. XII. Malhotra Publ. House.
- Lauria A & Ries VH. 2001. Floriculture – Fundamentals and Practices. Agrobios.
- Prasad S & Kumar U. 2003. Commercial Floriculture. Agrobios.
- Randhawa GS & Mukhopadhyay A. 1986. Floriculture in India. Allied Publ.
- Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007. Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

FLA 503 : PRODUCTION TECHNOLOGY FOR LOOSE FLOWERS 2+1

Objective

To impart basic knowledge about the importance and management of loose flowers grown in India.

Theory

UNIT I

Scope of loose flower trade, Significance in the domestic market/export, Varietal wealth and diversity, propagation, sexual and asexual propagation methods, propagation in mist chambers, nursery management, pro-tray nursery under shadenets, transplanting techniques

UNIT II

Soil and climate requirements, field preparation, systems of planting, precision farming techniques.

UNIT III

Water and nutrient management, weed management, rationing, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM.

UNIT IV

Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation.

UNIT V

Harvest indices, harvesting techniques, post-harvest handling and grading, packing and storage, value addition, concrete and essential oil extraction, transportation and marketing, export potential, institutional support, Agri Export Zones.

Crops: Jasmine, scented rose, chrysanthemum, marigold, tuberose,crossandra, nerium, hibiscus, barleria, celosia, gomphrena, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, lilies, tecoma, champaka, pandanus).

Practical

Botanical description of species and varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, storage and cold chain, project preparation for regionally important commercial loose flowers, visits to fields, essential oil extraction units and markets.

Suggested Readings

- Arora JS. 2006. Introductory Ornamental Horticulture. Kalyani.
- Bhattacharjee SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
- Bose TK & Yadav LP. 1989. Commercial Flowers. Naya Prokash.
- Bose TK, Maiti RG, Dhua RS & Das P. 1999. Floriculture and Landscaping. Naya Prokash.
- Chadha KL & Chaudhury B.1992. Ornamental Horticulture in India. ICAR.
- Chadha KL. 1995. Advances in Horticulture. Vol. XII. Malhotra Publ. House.
- Lauria A & Ries VH. 2001. Floriculture – Fundamentals and Practices. Agrobios.
- Prasad S & Kumar U. 2003. Commercial Floriculture. Agrobios.
- Randhawa GS & Mukhopadhyay A. 1986. Floriculture in India. Allied Publ.
- Sheela VL. 2007. Flowers in Trade. New India Publ. Agency.
- Valsalakumari PK, Rajeevan PK, Sudhadevi PK & Geetha CK. 2008. Flowering Trees. New India Publ. Agency.

FLA 504 : LANDSCAPING AND ORNAMENTAL GARDENING 2+1

Objective

Familiarization with principles and practices of landscaping and ornamental gardening.

Theory

UNIT I

Scope and Importance of landscape gardening, principles of landscape gardening, Landscape designs, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, Vanams, Buddha garden; Styles of garden, formal, informal and free style gardens.

UNIT II

Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, dam sites, IT parks, corporates.

UNIT III

Garden plant components, arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, bulbous plants, trees, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Production technology for selected ornamental plants.

UNIT IV

Lawns, Establishment and maintenance, special types of gardens, vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, colour wheels, temple garden, sacred groves.

UNIT V

Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeroscaping, hardscaping.

Practical

Selection of ornamental plants**,** practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens, burlapping, lawn making, planting herbaceous and shrubbery borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

Suggested Readings

- Bose TK, Maiti RG, Dhua RS & Das P. 1999. Floriculture and Landscaping. Naya Prokash.
- Lauria A & Victor HR. 2001. Floriculture – Fundamentals and Practices Agrobios.
- Nambisan KMP.1992. Design Elements of Landscape Gardening. Oxford & IBH.
- Randhawa GS & Mukhopadhyay A. 1986. Floriculture in India. Allied Publ.
- Sabina GT & Peter KV. 2008. Ornamental Plants for Gardens. New India Publ. Agency.
- Valsalakumari et al. 2008. Flowering Trees. New India Publ. Agency.
- Woodrow MG.1999. Gardening in India. Biotech Books.

FLA 505 : PROTECTED FLORICULTURE 2+1

Objective

Understanding the principles, theoretical aspects and developing skills in protected cultivation of flower crops.

Theory

UNIT I

Prospects of protected floriculture in India; Types of protected structures – Greenhouses, polyhouses, shade houses, rain shelters etc., Designing and erection of protected structures; Low cost/Medium cost/High cost structures – economics of cultivation; Location specific designs; Structural components; Suitable flower crops for protected cultivation.

UNIT II

Environment control – management and manipulation of temperature, light, humidity, air and CO2; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation.

UNIT III

Containers and substrates, media, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, IPM and IDM.

UNIT IV

Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.

UNIT V

Harvest indices, harvesting techniques, post-harvest handling techniques, Precooling, sorting, grading, packing, storage, quality standards.

Practical

Study of various protected structures, practices in design, layout and erection of different types of structures, practices in preparatory operations, soil decontamination techniques, practices in environmental control systems, practices in drip and fertigation techniques, special horticultural

practices, determination of harvest indices and harvesting methods, postharvest handling, packing methods, project preparation, visit to commercial greenhouses.

Suggested Readings

- Bhattacharjee SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
- Bose TK & Yadav LP. 1989. Commercial Flowers. Naya Prokash.
- Bose TK, Maiti RG, Dhua RS & Das P. 1999. Floriculture and Landscaping. Naya Prokash.
- Chadha KL. 1995. Advances in Horticulture. Vol. XII. Malhotra Publ. House.
- Lauria A & Victor HR. 2001. Floriculture – Fundamentals and Practices Agrobios.
- Nelson PV. 1978. Green House Operation and Management. Reston Publ. Co.
- Prasad S & Kumar U. 2003. Commercial Floriculture. Agrobios
- Randhawa GS & Mukhopadhyay A. 1986. Floriculture in India. Allied Publ.
- Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007. Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

FLA 506 : VALUE ADDITION IN FLOWERS 2+1

Objective

To develop understanding of the scope and ways of value addition in flowers.

Theory

UNIT I

Prospects of value addition, National and global scenario, production and exports, Women empowerment through value added products making, supply chain management.

UNIT II

Types of value added products, value addition in loose flowers, garlands, *veni*, floats, floral decorations, value addition in cut flowers, flower arrangement, styles, Ikebana, morubana, free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, etc.; Selection of containers and accessories for floral products and decorations.

UNIT III

Dry flowers– Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage.

UNIT IV

Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packing and storage, Selection of species and varieties, Types of pigments, carotenoids, anthocyanin, chlorophyll, betalains; Significance of natural pigments, Extraction methods; Applications.

Practical

Practices in preparation of bouquets, standard patterns of Western styles, button-holes, flower baskets, corsages, floral wreaths, Ikebana, garlands with fresh flowers; Techniques in flower arrangement; Techniques in floral decoration; Identification of plants for dry flower making; Practices in dry flower making; Preparation of dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths, etc.; Visit to florist shop and dry flower units, concrete and essential oil extraction units.

Suggested Readings

- Bhattacharjee SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
- Chadha KL.1995. Advances in Horticulture. Vol.XII. Malhotra Publ. House.
- Lauria A & Victor HR. 2001. Floriculture – Fundamentals and Practices Agrobios.
- Prasad S & Kumar U. 2003. Commercial Floriculture. Agrobios.
- Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007.Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

FLA 507 : TURFING AND TURF MANAGEMENT 2+1

Objective

To develop understanding of the principles and management of turfing.

Theory

UNIT I

Prospects of landscape industry; History of landscape gardening, site selection, basic equirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment.

UNIT II

Turf grasses - Types, species, varieties, hybrids; Selection of grasses for different locations; Grouping according to climatic requirement- Adaptation; Turfing for roof gardens.

UNIT III

Preparatory operations; Growing media used for turf grasses – Turf establishment methods, seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding, astro-turfing.

UNIT IV

Turf management – Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing -- mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs.

UNIT V

Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, etc.

Practical

Identification of turf grasses, Preparatory operations in turf making, Practices in turf establishment, Layout of macro and micro irrigation systems, Water and nutrient management; Special practices – mowing, raking, rolling, soil top dressing, weed management; Biotic and abiotic stress management; Project preparation for turf establishment, visit to IT parks, model cricket and golf grounds, airports, corporates, Govt. organizations; Renovation of lawns; Turf economics.

Suggested Readings

- Nick-Christians 2004. Fundamentals of Turfgrass Management. www.amazon.com

FLA 508 : CAD FOR OUTDOOR AND INDOORSCAPING 2+1

Objective

To impart basic knowledge about the operation of Computer Aided Designing (CAD) in landscape garden designing.

Theory

UNIT I

Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing.

UNIT II

2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects.

UNIT III

Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking, Script making, Using productivity tools, e-transmit file, making sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout.

UNIT IV

3D drawing methods, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD.

UNIT V

ARCHICAD organization tools, Dimensioning and detailing of designs, Attribute settings of components, Visualization tools for landscape preview, Data management, plotting and accessories for designing, Inserting picture using photoshop, Making sample drawing for outdoor and indoor gardens.

Practical

Identification of various software for CAD, Practices in point picking methods, Using tool bars and icons, Using modifying tools and modifying comments, Isometric drawings, Using productivity tools, Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden, Using tools and info-box for 3D drawing, Creation of garden components with ARCHICAD, Organization, dimensioning, detailing and visualization tools with ARCHICAD, Using Photoshop package for 3D picture insertion, Drawing designs with ARCHICAD for home garden, interior garden designing, IT parks, Corporates, Theme parks and Ecotourism spots.

Suggested Readings

- Christine Wein-Ping Yu 1987. Computer-aided Design: Application to Conceptual Thinking in Landscape Architecture. amazon.com

FLA 601 : ADVANCES IN BREEDING OF FLOWER CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of flower crops with special emphasis on crops grown in India.

Theory

UNIT I

Origin and evolution of varieties, distribution, Genetic resources, genetic divergence, Plant introduction, selection and domestication, Inheritance of important characters, Genetic mechanisms associated with flower colour and flower size, doubleness, fragrance and post-harvest life, Plant Variety Protection Act.

UNIT II

Specific objectives of breeding in flower crops, Methods of breeding suited to seed and vegetatively propagated flower crops, Introduction, selection, polyploidy and mutation breeding in the evolution of new varieties, Exploitation of heterosis, utilization of male sterility-Incompatibility problems. *In Vitro* breeding.

UNIT III

Breeding for resistance to pests, diseases, nematodes and other biotic and abiotic stresses in flower crops.

UNIT IV

Specific breeding problems and achievements made in rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, gerbera, gladioli, orchids and anthurium.

UNIT V

Specific breeding problems and achievements made in aster, petunia, liliums, heliconia, bird of paradise, hibiscus and bougainvillea.

Practical

Description of crops and cultivars; Cataloguing of species and cultivars, floral biology, selfing and crossing, evaluation of hybrid progenies; Induction of mutants; Physical and chemical mutagens; Induction of polyploidy; Screening of plants for biotic and abiotic stresses and environmental pollution; *in-vitro* breeding in flower crops.

Suggested Readings

- Arora JS. 2006. Introductory Ornamental Horticulture. Kalyani.
- Bhattacharjee SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
- Choudhary RC.1993. Introduction to Plant Breeding. Oxford & IBH.
- Singh BD.1990. Plant Breeding. Kalyani.

FLA 602 : ADVANCES IN FLOWER PRODUCTION TECHNOLOGY 2+1

Objective

To keep abreast with latest developments and trends in production technology of flower crops.

Theory

UNIT I

Commercial flower production; Scope and importance; Global Scenario in cut flower production and trade, varietal wealth and diversity; Soil and Environment; Special characteristics and requirements; cut flower, loose flowers, dry flowers and floral oil trade.

UNIT II

Propagation and multiplication; IPR issues related to propagation of materials; Greenhouse management; Soil/media decontamination techniques; Micro-irrigation; nutrition and fertigation; slow release fertilizers and bio-fertilizers; influence of environmental parameters, light, temperature, moisture, humidity and CO2 on growth and flowering; regulation for quality flowers.

UNIT III

Flower forcing and year-round flowering through physiological interventions; Chemical regulation; Environmental manipulation; Harvest indices; Harvesting techniques; Post-harvest handling; Pre-cooling, pulsing, packing, marketing; Export potential; Agri Export Zones.

UNIT IV

Crop specific practices – rose, anthurium, orchids, carnation, gladioli, gerbera, liliums, heliconia, bird of paradise, *Jasminum* sp., marigold, tuberose, crossandra, spider lily, gaillardia, chrysanthemum

UNIT V

Floral oil industry, floral concrete production, extraction methods, recent advances.

Practical

Varietal wealth in flower crops; Greenhouse management; Soil decontamination techniques; Microirrigation; Nutrition and fertigation. Special practices- Pinching, netting, disbudding, defoliation and chemical pruning; Photoperiodic and chemical induction of flowering; Assessing harvest indices; Post-harvest handling; Tissue analysis; Preparation of floral decoratives; Extraction of floral concrete and oils; case studies; visit to commercial cut flower units.

Suggested Readings

- Bose TK, Maiti RG, Dhua RS & Das P. 1999. Floriculture and Landscaping. Naya Prokash.
- Chadha KL & Choudhury B. 1992. Ornamental Horticulture in India. ICAR.
- George S & Peter KV. 2008. Plants in a Garden. New India Publ. Agency.
- Lauria A & Victor HR. 2001. Floriculture – Fundamentals and Practices. Agrobios.
- Randhawa GS & Mukhopadhyay A. 1986. Floriculture in India. Allied Publ.
- Reddy S, Janakiram B, Balaji T, Kulkarni. S & Misra RL. 2007. Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

FLA 603 : ADVANCES IN PROTECTED AND PRECISION FLORICULTURE 1+1

Objective

Appraisal on the advances in protected and precision farming of flower crops.

Theory

UNIT I

Prospects of protected floriculture in India, growing structures, basic considerations in establishment and operation of green houses, functioning and maintenance.

UNIT II

Environmental control systems in greenhouse, containers, substrate culture, soil decontamination techniques.

UNIT III

Water and nutrient management, crop regulation, special horticultural practices under protected cultivation of rose, chrysanthemum, carnation, orchids, anthurium, gerbera, liliums, heliconia, cut foliage; Harvest indices – harvesting, PH handling, marketing, export.

UNIT IV

Precision floriculture, Principles and concepts, Enabling technologies of precision farming, GPS, GIS, Remote sensing, sensors.

UNIT V

Variability management in precision farming, mapping, variable rate technology, precision equipments, computers and robotics in precision farming, post-harvest process management in floriculture using precision farming.

Practical

Growing structures, basic considerations in establishment and operation of greenhouses, Environmental control systems in greenhouse, containers, substrate culture, soil decontamination techniques, Crop regulation, special horticultural practices under protected cultivation, precision equipments, computers and robotics in precision farming, post-harvest process management in floriculture using precision farming.

Suggested Readings

- Bhattacharjee SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
- Bose TK, Maiti RG, Dhua RS & Das P. 1999. Floriculture and Landscaping. Naya Prokash.
- Reddy S, Janakiram B, Balaji T, Kulkarni S, & Misra RL. 2007. Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

FLA 604 : ADVANCES IN LANDSCAPE ARCHITECTURE 1+2

Objective

To update knowledge on the recent trends in the field of landscape architecture and developing practical skills.

Theory

UNIT I

Commercial landscape gardening- History, Plant identification and ecology, Materials of garden design, Design making by different garden styles and types, different basic design elements land, plant material, water, buildings, pavements, etc.

UNIT II

Expenses to model landscaping units of all category, Creativity and communication skills for landscape architect, Way of designing a commercial landscape project.

UNIT III

Assessing site and plants adaptability for different locations, Landscape engineering (Topographical) survey and designing concept), special techniques in garden landscaping (Burlaping, waterscaping, hardscaping, lawn making, topiary styles specializing, bioaesthetic planning).

UNIT IV

Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing.

UNIT V

Contemporary landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Case study with the successful landscapist, Budget / Project cost estimating, Execution strategies, Assessing a successful design in site.

Practical

Commercial landscaping, Plant identification, Materials of garden design, Design making by different garden styles and types. Way of designing a commercial landscape project, visit to model ornamental nursery. Assessing site and plants adaptability for different locations, Landscape engineering (Topographical survey and designing concept), special techniques in garden landscaping (Burlaping, waterscaping, hardscaping, lawn making, topiary styles specializing, bioaesthetic planning). Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing. Contemporary landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Case study with the successful landscapist, Budget/Project cost estimating, Execution.

Suggested Readings

- Bose TK, Maiti RG, Dhua RS & Das, P. 1999. Floriculture and Landscaping. Naya Prokash.
- Nambisan KMP. 1992. Design Elements of Landscape Gardening. Oxford & IBH.

FLA 605 : ADVANCES IN BIOCHEMISTRY AND BIOTECHNOLOGY OF FLOWERS 2+1

Objective

Appraisal on the advances in biochemistry of flowers and application of biotechnology in flower crops.

Theory

UNIT I

Biochemistry of flowers: Principle involved in the formation of pigments – chlorophyll, xanthophyll, carotenoids, flavonoids and anthocyanins. Chemistry and importance of secondary metabolites in rose, jasmine, marigold, tuberose, carnation, orchids, liliums and bougainvillea.

Biochemistry and utilization commercial products (select items).

UNIT II

Recent trends- Extraction of biocolours and their value addition, uses in food and textile industries. Biochemistry of post harvest management of cut flowers.

UNIT III

Biotechnology – tools techniques and role in floriculture industry, physical factors and chemical factors influencing the growth and development of plant cell, tissue and organs, cyto-differentiation, organogenesis, somatic embryogenesis.

UNIT IV

In vitro lines for biotic and abiotic stress – Meristem culture for disease elimination, production of haploids through anther and pollen culture – embryo and ovule culture, micrografting, wide hybridization and embryo rescue techniques, construction of somatic hybrids and cybrids, regeneration and characterization of hybrids and cybrids, *in vitro* pollination and fertilization, hardening media, techniques and establishment of tissue culture plants in the primary and secondary nursery.

UNIT V

Somoclonal variation and its applications – variability induction through *in vitro* mutation, development of cell suspension cultures, types and techniques, *in vitro* production of secondary metabolites, role of bioreactors in production of secondary metabolites, quantification and

quality analysis of secondary metabolites using HPLC, *in vitro* conservation and cryo-preservation techniques.

UNIT VI

Gene cloning, genetic engineering: vectors and methods of transformation – electroporation, particle bombardment, *Agrobacterium* mediated, transgenic plants in flower crops, medicinal and aromatic crops, isolation of DNA, RNA, quantification, Polymerase Chain Reaction for amplification; AGE & PAGE techniques; identification of molecular markers.

UNIT VII

Construction of c- DNA library, DNA fingerprinting technique in economic flower crop varieties, molecular approaches to control ethylene response, improving shelf life, improving resistance for environmental stress, approaches to improve flower development, pigment production, secondary metabolite production, post harvest biotechnology of flowers, ornamental plants, achievements of bio-technology in flower crops.

Practical

Extraction of flower pigments – xanthophylls, carotenoids and anthocyanins. Plant nutrient stock- growth regulators- media preparation and sterilization- *In vitro* seed germination- callus culture and organ culture- Cell suspension culture – cell plating and regeneration- clonal propagation through Meristem culture, induction of multiple shoots- Anther- Pollen- Ovule and Embryo culture- Synthetic seed production, *in vitro* mutation induction, *in vitro* rooting – hardening at primary and secondary nurseries, Project preparation for establishment of low, medium and high cost tissue culture laboratories, DNA isolation from economic flower crop varieties – Quantification and amplification, DNA and Protein profiling – molecular markers for economic flower crops, restriction enzymes, vectors for cloning and particle bombardment, DNA fingerprinting of flower crop varieties.

Suggested Readings

- Chopra VL & Nasim. 1990. Genetic Engineering and Biotechnology – Concepts, Methods and Applications. Oxford & IBH.
- Debnath M. 2005. Tools and Techniques of Biotechnology. Pointer Publ.
- Dey PM & Harborne JB. 1997. Plant Biochemistry. 2nd Ed. Academic Press.
- Glover MD. 1984. Gene Cloning: The Mechanics of DNA Manipulation. Chapman & Hall.
- Goodwin TW & Mercer EI. 2003. Introduction to Plant Biochemistry. CBS.
- Gorden H & Rubsell S. 1960. Hormones and Cell Culture. AB Book Publ.
- Keshavachandran R & Peter KV. 2008. Plant Biotechnology: Methods in Tissue Culture and Gene Transfer. Orient & Longman (Universal Press).
- Keshavachandran R, Nazeem PA, Girija D, John PS & Peter KV. (Eds.). 2007. Recent Trends in Horticultural Biotechnology. Vols. I, II. New India Publishing Agency.
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- Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK & Mohanadas S. 2001. Biotechnology of Horticultural Crops. Vols. I-III. Naya Prokash.
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- Prasad S. 1999. Impact of Plant Biotechnology on Horticulture. 2nd Ed. Agro Botanica.
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PLANTATION, SPICES, MEDICINAL & AROMATIC CROPS

PSMA 501 : PRODUCTION OF PLANTATION CROPS 2+1

Objective

To impart basic knowledge about the importance and production technology of plantation crops grown in India.

Theory

Role of plantation crops in national economy, export potential, IPR issues, clean development mechanism, classification and varietal wealth. Plant multiplication including *in vitro* multiplication, systems of cultivation, multitier cropping, photosynthetic efficiencies of crops at different tiers, rainfall, humidity, temperature, light and soil pH on crop growth and productivity, high density planting, nutritional requirements, physiological disorders, role of growth regulators and macro and micro nutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management, training and pruning, crop regulation, maturity indices, harvesting. Cost benefit analysis, organic farming, management of drought, precision farming.

Crops

UNIT I: Coffee and tea
UNIT II: Cashew and cocoa
UNIT III: Rubber, palmyrah and oil palm
UNIT IV: Coconut and arecanut
UNIT V: Wattle and betel vine

Practical

Description of botanical and varietal features, selection of mother palms and seedlings in coconut and arecanut, soil test crop response studies and manuring practices, pruning and training, maturity standards, harvesting, Project preparation for establishing plantations, Visit to plantations.

Suggested Readings

- Anonymous, 1985. Rubber and its Cultivation. The Rubber Board of India.
- Chopra VL & Peter KV. 2005. Handbook of Industrial Crops. Panima.
- Harler CR. 1963. The Culture and Marketing of Tea. Oxford Univ. Press.
- Kurian A & Peter KV. 2007. Commercial Crops Technology. New India Publ. Agency.
- Nair MK, Bhaskara Rao EVV, Nambiar KKN & Nambiar MC. 1979. Cashew. CPCRI, Kasaragod.
- Peter KV. 2002. Plantation Crops. National Book Trust.
- Pradeep Kumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008.
- Management of Horticultural Crops. Part I, II. New India Publ. Agency.
- Rai PS & Vidyachandram B. 1981. Review of Work Done on Cashew. UAS, Research Series No.6, Bangalore.

- Ranganathan V. 1979. Hand Book of Tea Cultivation. UPASI, Tea Res. Stn. Cinchona.
- Srivastava HC, Vatsaya B & Menon KKG. 1986. Plantation Crops –Opportunities and Constraints. Oxford & IBH.
- Thampan PK. 1981. Hand Book of Coconut Palm. Oxford & IBH.

PSMA 502 : PRODUCTION TECHNOLOGY OF SPICE CROPS 2+1

Objective

To impart basic knowledge about the importance and production technology of spices grown in India.

Theory

Introduction, importance of spice crops-historical accent, present status - national and international, future prospects, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, site selection, layout, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed planting material and micro-propagation, precision farming, organic resource management, organic certification, quality control, pharmaceutical significance and protected cultivation of:

UNIT I

Black pepper, cardamom

UNIT II

Clove, cinnamon and nutmeg, allspice

UNIT III

Turmeric, ginger and garlic

UNIT IV

Coriander, fenugreek, cumin, fennel, ajowain, dill, celery

UNIT V

Tamarind, garcinia and vanilla

Practical

Identification of seeds and plants, botanical description of plant; preparation of herbarium, propagation, nursery raising, field layout and method of planting, cultural practices, harvesting, drying, storage, packaging and processing, value addition; short term experiments on spice crops.

Suggested Readings

- Agarwal S, Sastry EVD & Sharma RK. 2001. Seed Spices: Production, Quality, Export. Pointer Publ.
- Arya PS. 2003. Spice Crops of India. Kalyani.
- Bhattacharjee SK. 2000. Hand Book of Aromatic Plants. Pointer Publ.
- Bose TK, Mitra SK, Farooqi SK & Sadhu MK (Eds.). 1999. Tropical Horticulture. Vol.I. Naya Prokash.
- Chadha KL & Rethinam P. (Eds.). 1993. Advances in Horticulture. Vols. IX-X. Plantation Crops and Spices. Malhotra Publ. House.
- Gupta S. (Ed.). Hand Book of Spices and Packaging with Formulae. Engineers India Research Institute, New Delhi.
- Kumar NA, Khader P, Rangaswami & Irulappan I. 2000. Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants. Oxford & IBH.
- Nybe EV, Miniraj N & Peter KV. 2007. Spices. New India Publ. Agency.
- Parthasarthy VA, Kandiannan V & Srinivasan V. 2008. Organic Spices. New India Publ. Agency.
- Peter KV. 2001. Hand Book of Herbs and Spices. Vols. I-III. Woodhead Publ. Co. UK and CRC USA
- Pruthi JS. (Ed.). 1998. Spices and Condiments. National Book Trust
- Pruthi JS. 2001. Minor Spices and Condiments- Crop Management and Post Harvest Technology. ICAR.
- Purseglove JW, Brown EG, Green CL & Robbins SRJ. (Eds.). 1981. Spices. Vols. I, II. Longman.

- Shanmugavelu KG, Kumar N & Peter KV. 2002. Production Technology of Spices and Plantation Crops. Agrobios.
- Thamburaj S & Singh N. (Eds.). 2004. Vegetables, Tuber Crops and Spices. ICAR.
- Tiwari RS & Agarwal A. 2004. Production Technology of Spices. International Book Distr. Co.
- Varmudy V. 2001. Marketing of Spices. Daya Publ. House.

PSMA 503 : PRODUCTION TECHNOLOGY FOR MEDICINAL AND AROMATIC CROPS 2+1

Objective

To impart comprehensive knowledge about the production technology of medicinal and aromatic crops.

Theory

UNIT I

History of *Ayurveda*, *Siddha* and *Unani* medicines, present status and future scope, Herbal industry, WTO scenario, Export and import status, Indian system of medicine, Indigenous Traditional Knowledge, IPR issues, Classification of medicinal crops, Systems of cultivation, Organic production, Role of institutions and NGO's in production and marketing, GAP in medicinal crop production. Role of importance of spices as medicines.

UNIT II

Production technology for Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Sarpagandha, *Dioscorea* sp., *Aloe vera*, *Phyllanthus amarus, Andrographis paniculata, Phyllanthus emblica (aonla), Terminellia chebula (Harde) and Terminellia bellirica(Baheda).Piper longum (pippali),*

UNIT III

Production technology for Medicinal solanum, Isabgol, Poppy, Safed musli, *Stevia rebaudiana, Mucuna pruriens, Ocimum sp.*

UNIT IV

Post harvest handling – Drying, Processing, Grading, Packing and Storage, processing and value addition; GMP and Quality standards in herbal products.

UNIT V

Influence of biotic and abiotic factors on the production of secondary metabolites, Regulations for herbal raw materials, Phytochemical extraction techniques.

UNIT VI

Importance and classification, Aromatic industry, WTO scenario, Export and import status, Indian perfumery industry, History, Advancements in perfume industry. Information on aroma therapy.

UNIT VII

Production technology for palmarosa, lemongrass, citronella, **v**etiver, geranium, artemisia, mentha, ocimum, eucalyptus, rosemary, thyme, patchouli, lavender, marjoram, oreganum. Rose, tuberose and jasmine.

UNIT VIII

Post-harvest handling, Distillation methods, advanced methods, Solvent extraction process, steam distillation, Perfumes from non-traditional plants, Quality analysis, Value addition, Aroma chemicals, quality standards and regulations, problems in oil extraction.

UNIT IX

Institutional support and international promotion of essential oil and perfumery products.

Practical

Botanical description, Propagation techniques, Maturity standards, Digital documentation, Extraction of secondary metabolites, Project preparation for commercially important medicinal crops, Visit to medicinal crop fields, Visit to herbal extraction units. Extraction of Essential oils, Project preparation for commercially important Aromatic crops, Visit to distillation and value addition units – Visit to CIMAP.

Suggested Readings

- Atal CK & Kapur BM. 1982. Cultivation and Utilization of Aromatic Plants. RRL, CSIR, Jammu.
- Atal CK & Kapur BM. 1982. Cultivation and Utilization of Medicinal Plants. RRL, CSIR, Jammu.

- Farooqi AA & Sriram AH. 2000. Cultivation Practices for Medicinal and Aromatic Crops. Orient Longman Publ.
- Farooqi AA, Khan MM & Vasundhara M. 2001. Production Technology of Medicinal and Aromatic Crops. Natural Remedies Pvt. Ltd.
- Hota D. 2007. Bio Active Medicinal Plants. Gene Tech Books.
- Jain SK. 2000. Medicinal Plants. National Book Trust.
- Khan IA & Khanum A. Role of Bio Technology in Medicinal and Aromatic Plants. Vol. IX. Vkaaz Publ.
- Kurian A & Asha Sankar M. 2007. Medicinal Plants. Horticulture Science Series, New India Publ. Agency.
- Panda H. 2002. Medicinal Plants Cultivation and their Uses. Asia Pacific Business Press.
- Prajapati SS, Paero H, Sharma AK & Kumar T. 2006. A Hand book of Medicinal Plants. Agro Bios.
- Ramawat KG & Merillon JM. 2003. BioTechnology-Secondary Metabolites. Oxford & IBH.
- Skaria P Baby, Samuel Mathew, Gracy Mathew, Ancy Joseph, Ragina Joseph. 2007. Aomatic Plants. New India Publ. Agency.

PSMA 504 : BREEDING OF PLANTATION CROPS AND SPICES 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of plantation crops and spices.

Theory

Species and cultivars, cytogenetics, survey, collection, conservation and evaluation, blossom biology, breeding objectives, approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploid breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, molecular aided breeding and biotechnological approaches, marker-assisted selection, bioinformatics, IPR issues, achievements and future thrusts.

Crops

UNIT I: Coffee and tea
UNIT II: Cashew and cocoa
UNIT III: Rubber, palmyrah and oil palm
UNIT IV: Coconut and arecanut
UNIT V: Black pepper and cardamom
UNIT VI: Ginger and turmeric
UNIT VII: Fenugreek, coriander, fennel, celery and ajwoain
UNIT VIII: Nutmeg, cinnamon, clove and allspice

Practical

Characterization and evaluation of germplasm accessions, Blossom biology, studies on pollen behaviour, practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for biotic and abiotic stresses, haploid culture, protoplast culture and fusion- induction of somaclonal variation and screening the variants. Identification and familiarization of spices; floral biology anthesis; fruit set; selfing and crossing techniques; description of varieties. Salient features of improved varieties and cultivars from public and private sector, bioinformatics, visit to radiotracer laboratory, national institutes for plantation crops and plant genetic resource centers, genetic transformation in plantation crops for resistance to biotic stress/quality improvement etc.

Suggested Readings

- Anonymous 1985. Rubber and its Cultivation. The Rubber Board of India.
- Chadha KL & Rethinam P. (Eds.).1993. Advances in Horticulture. Vol. IX. Plantation Crops and Spices. Part-I. Malhotra Publ. House.
- Chadha KL, Ravindran PN & Sahijram L. 2000. Biotechnology in Horticultural and Plantation Crops. Malhotra Publ. House.
- Chadha KL. 1998. Advances in Horticulture. Vol. IX. Plantation and Spices Crops. Malhotra Publishing House, New Delhi.
- Chopra VL & Peter KV. Handbook of Industrial Crops. Haworth Press.
- Panama International Publishers, New Delhi (Indian Ed.).

- Damodaran VK, Vilaschandran T &.Valsalakumari PK. 1979. Research on Cashew in India. KAU, Trichur.
- Ferwerden FP & Wit F. (Ed.). 1969. Outlines of Perennial Crop Breeding in the Tropics. H. Veenman & Zonen.
- Harver AE. 1962. Modern Coffee Production. Leonard Hoff.
- Raj PS & Vidyachandra B. 1981. Review of Work Done on Cashew. UAS Research Series No.6, Bangalore.
- Thampan PK 1981. Hand Book of Coconut Palm. Oxford & IBH.

PSMA 505 : BREEDING OF MEDICINAL AND AROMATIC CROPS 2+1

Objective

To impart comprehensive knowledge about the principles and practices of breeding of plantation crops and spices.

Theory

UNIT I

Plant bio-diversity, conservation of germplasm, IPR issues, Major objectives of breeding of Medicinal and Aromatic Crops, Scope for introduction; cytogenetic background of important Medicinal and Aromatic Crops; Scope for improvement of Medicinal and Aromatic Crops through selection, intra and interspecific hybridization, induced autotetraploidy, mutation breeding and biotechnological approaches.

UNIT II

Breeding for yield and quality improvement in medicinal plants, Breeding for high herbage yield, essential oil and quality components, secondary metabolites in medicinal and aromatic crops; Genetics of active principles and assay techniques useful in evaluation of breeder's material. Breeding problems in seed and vegetatively propagated medicinal and aromatic crops.

UNIT III

Achievements and prospects in breeding of medicinal crops, *viz*. *Cassia angustifolia*, *Catharanthus roseus*, *Gloriosa superba*, *Coleus forskohlii*, Stevia, *Withania somnifera*, *Papaver somniferum*, *Plantago ovata*, *Dioscorea* sp.

UNIT IV

Prospects in breeding of medicinal crops, *viz. Chlorophytum* sp, *Rauvolfia serpentina*, *Aloe vera, Ocimum* sp*, Phyllanthus amarus, Solanum* sp.

UNIT V

Prospects in breeding of aromatic crops viz., Geranium, vettiver, Lemon grass, Palmarosa, citronella, Rosemary, Patchouli, Eucalyptus, Artemisia and Mint.

Practical

Description of Botanical features, Cataloguing of cultivars, varieties and species in medicinal and aromatic crops, Floral Biology, Selfing and crossing, Evaluation of hybrid progenies, Induction of economic mutants, High alkaloid and high essential oil mutants, evolution of mutants through physical and chemical mutagens, Introduction of polyploidy, Screening of plants for biotic and abiotic stress and environmental pollution, *in-vitro* breeding in medicinal and aromatic crops.

Suggested Readings

- Atal CK & Kapur BM. 1982. Cultivation and Utilization of Medicinal Plants. RRL, CSIR, Jammu.
- Chadha KL & Gupta R. 1995. Advances in Horticulture. Vol. XI. Malhotra Publ. House.
- Farooqi AA, Khan MM & Vasundhara M. 2001. Production Technology of Medicinal and Aromatic Crops. Natural Remedies Pvt. Ltd.
- Jain SK. 2000. Medicinal Plants. National Book Trust.
- Julia F & Charters MC. 1997. Major Medicinal Plants – Botany, Cultures and Uses. Thomas Publ.
- Kurian A & Asha Sankar, M. 2007. Medicinal Plants. Horticulture Science Series, New India Publ. Agency.
- Prajapati ND, Paero Hit SS, Sharma AK, Kumar T. 2006. A Hand book of Medicinal Plants. Agro Bios (India).
- Skaria P Babu. 2007. Aromatic Plants. New India Publ. Agency.

❖ Thakur RS, Pauri HS & Hussain A. 1989. Major Medicinal Plants of India. CSIR.

PSMA 506 : PROCESSING OF PLANTATION CROPS, SPICES MEDICINAL AND AROMATIC PLANTS 2+1

Objective

To facilitate deeper understanding on principles and practices of post harvest technology of plantation crops, spices, medicinal and aromatic crops.

Theory

UNIT I

Commercial uses of spices and plantation crops. Processing of major spices - cardamom, black pepper, ginger, turmeric, chilli and paprika,vanilla, cinnamon, clove, nutmeg, allspice, coriander, fenugreek, curry leaf. Extraction of oleoresin and essential oils.

UNIT II

Processing of produce from plantation crops, *viz*. coconut, arecanut, cashewnut, oil palm, palmyrah, date palm, cocoa, tea, coffee, rubber etc.

UNIT III

Processing of medicinal plants– dioscorea, gloriosa, stevia, coleus, ashwagandha, tulsi, isabgol, safed musli, senna, aloe, catharanthus, etc. Different methods of drying and storage. Microbial contamination of stored product. Influence of temperature and time combination on active principles.

UNIT IV

Extraction and analysis of active principles using TLC / HPLC / GC. Distillation, solvent extraction from aromatic plants– davana, mint, rosemary, rose, citronella, lavender, jasmine, etc. Study of aroma compounds and value addition. Nano-processing technology in medicinal and aromatic plants.

Practical

Study of processing of different spices and plantation crops. Study of processing of medicinal plants, their drying and storage. Extraction of active ingredients from different spices and herbs using TLC, HPLC, GC/CG-MS technology. Distillation, solvent extraction from aromatic plants – davana, mint, rosemary, citronella, lavender, jasmine, etc. Identification of different odoriferous factors in essential oil with GLC/GCMS. Physico-chemical and sensory evaluation of oils and oleoresin. Value added products from spices and plantation crops.

Suggested Readings

❖ Chadha KL et al. (Eds.). 1993-95. Advances in Horticulture. Vol. IX. Plantation Crops and Spices. Malhotra Publishing House, New Delhi.
❖ Fellows PJ. 1988. Food Processing Technology. Ellis Horwood International. Switzerland.
❖ Fennema OR. 1985. Food Chemistry. Marcel Dekker.
❖ Kumar N, Abdul Khader ML, Rangaswamy P & Ikrulappan I. 1994. Spices, Plantation Crops, Medicinal and Aromatic Plants. Rajalakshmi Publ.
❖ Mandal RC. 1996. Coconut Production and Processing Technology. Agro. Bot.
❖ Mandal RC. 1997. Cashew: Production and Processing Technology. Agro. Bot.
❖ Masada Y.1986. Analysis of Essential Oil by Gas Chromatograph and Mass Spectrometry. John Wiley & Sons.
❖ Paine FA. 1987. Modern Processing, Packaging and Distributions Systems for Food. AVI Publ.
❖ Peter KV. (Ed.). 2001. Handbook of Herbs and Spices. Vols.I-III. WoodHead Publishing Co., UK & CRC, USA.
❖ Sudheer KP & Indira V. 2008. Post-Harvest Technology of Horticultural Crops. Horticulture Science Series. New India Publ. Agency.
❖ Thampan PK. 1981. Handbook of Coconut Palm. Oxford & IBH.

PSMA 507 : ORGANIC SPICE AND PLANTATION CROP PRODUCTION TECHNOLOGY 2+1

Objective

To educate principles, concepts and production of organic farming in spice and plantation crops.

Theory

UNIT I

Importance, principles, perspective, concept and component of organic production of spice and plantation crops.

UNIT II

Organic production of spice crops and plantation crops, *viz.* pepper, cardamom, turmeric, ginger, cumin, vanilla, coconut, coffea, cocoa, tea, arecanut.

UNIT III

Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.

UNIT IV

Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, Panchagavvya, Biodynamics, preparation etc.; Pest and disease management in organic farming; ITK's in organic farming. Role of botanicals and bio-control agents.

UNIT V

GAP and GMP- Certification of organic products; organic production and export - opportunity and challenges.

Practical

Method of preparation of compost, vermicomposting, biofertilizers, soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, waste management, organic soil amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Readings

- Dahama AK. 2005. Organic Farming for Sustainable Agriculture. 2nd Ed. Agrobios.
- Gehlot G. 2005. Organic Farming: Standards, Accreditation, Certification and Inspection. Agrobios.
- Palaniappan SP & Annadorai K. 2003. Organic Farming: Theory and Practice. Scientific Publ.
- Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. Management of Horticultural Crops. New India Publ. Agency.
- Shivashankar K. 1997. Food Security in Harmony with Nature. 3rd IFOAMASIA, Scientific Conference. 1-4 Dec., 1997, UAS, Bangalore.

PSMA 508 : UNDEREXPLOITED MEDICINAL AND AROMATIC CROPS 1+1

Objective

To facilitate understanding on the importance, conservation and cultivation of medicinal and aromatic crops.

Theory

UNIT I

Introduction, importance, present status and future prospects, origin, distribution, species, varieties, economic parts and their uses in different diseases, Biodiversity and conservation, RET (Rare, Endangered and Threatened) and MPCAs (Medicinal Plants Conservation Areas).

UNIT II

Underutilized species – importance, traditional usage, ISM, TCM, Functional foods.

UNIT III

Production technology of underutilized medicinal crops– *Morinda citrifolia, Caesalpinia sappan*, *Caralluma, Terminalia chebula, Strychnos nuxvomica, Solanum trilobatum,* Physalis, *Aegle marmelos, Alpinia* sp., *Anthocephalus kadamba, Costus.*

UNIT IV

Production technology of underutilized aromatic crops– *Curcuma aromatica, C. caesia, Coleus aromaticus, Ocimum kilimanjaricum, Bursera.*

UNIT V

National and international conservation network, IPR issues, Promotion of under utilized species, Processing and value addition, Marketing.

Practical

Case studies.

Suggested Readings

- Atal CK & Kapur BM. 1982. Cultivation and Utilization of Aromatic Plants. RRL, CSIR, Jammu.
- Atal CK & Kapur BM. 1982. Cultivation and Utilization of Medicinal Plants. RRL, CSIR, Jammu.
- Chadha KL Gupta. R. 1995. Advance in Horticulture. Vol. XI. Medicinal & Aromatic Plants. Malhotra Publ. House.
- CSIR. 1971. The Wealth of India. Vols. A-Z. CSIR.
- Farooqui AA, Khan MM & Sreeramu BS. 1997. Cultivation of Medicinal and Aromatic Crops in India. Naya Prokash.
- Guenther E. 1975. The Essential Oils. Robert K. Krieger Publ. Co. Jain SK. 1979. Medicinal Plants. National Book Trust.
- Kurian A & Asha Sankar M. 2007. Medicinal Plants. Horticulture Science Series, New India Publ. Agency.
- Peter KV. (Ed.). 2007-08. Underexploited and Underutilized Horticultural Crops. Vols.I-IV. New India Publ. Agency.
- Sivarajan VV & Balachandran I. 1994. Ayurvedic Drugs and their Plant Sources. Oxford & IBH.

PSMA 601 : ADVANCES IN PRODUCTION OF PLANTATION CROPS 2+1

Objective

To keep abreast with latest developments and trends in production technology of plantation crops.

Theory

Plantation crops – area and production, export potential - varietal wealth and appraisal on the crop improvement in plantation crops. Mass multiplication techniques, High density planting, systems of cultivation,multitier cropping, companion cropping, studies of on canopy and root management, photosynthetic efficiencies of crops at different tiers, Biotic and abiotic factors on growth and productivity, nutritional requirements, role of macro and micro nutrients, Nutrient deficiency symptoms, growth regulators, water requirement, fertigation, soil and moisture conservation practices, Drought management, permanent vegetation management, Basin management, training and pruning, maturity indices, harvesting, curing, processing and value addition, grading, packing and storage, role of commodity boards in plantation crop development, Production of plantation crops through GAP, GMP, HACCP.

Crops

UNIT I: Coffee and tea
UNIT II: Cashew and cocoa
UNIT III: Rubber, palmyrah and oil palm
UNIT IV: Coconut and arecanut
UNIT V: Wattle and betelvine

Practical

Description of botanical and varietal features-selection of mother palms and elite clones, Clonal fidelity testing, nursery techniques and propagation methods, High density planting, training and pruning practices, fertigation and foliar nutrition, shade regulation, maturity standards, harvesting, curing, processing and grading, project preparation for establishing new plantations, visit to plantation gardens, commodity boards and plantation based industries.

Suggested Readings

- Anonymous 1985. Rubber and its Cultivation. The Rubber Board of India.
- Grimwood BE. 1975. Coconut Palm Products. FAO.
- Kurian A & Peter KV. 2007. Commercial Crops Technology. New India Publ. Agency.
- Nair MK, Bhaskara Rao EVV, Nambiar KKN & Nambiar MC. 1979. Cashew. CPCRI, Kasaragod.
- Patel JS. 1938. The Coconut – A Monograph. Govt. Press, Madras.

- Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2007. Management of Horticultural Crops. Parts I, II. New India Publ. Agency.
- Rai PS & Vidyachandram B. 1981. Review of Work Done on Cashew. UAS Research Series No.6, Bangalore.
- Ranganathan V. 1979. Hand Book of Tea Cultivation. UPASI, Tea Res. Stn. Cinchona.
- Srivastava HC, Vatsaya B & Menon KKG. 1986. Plantation Crops –Opportunities and Constraints. Oxford & IBH.
- Thampan PK. 1981. Hand Book of Coconut Palm. Oxford & IBH.

PSMA 602 : ADVANCES IN SPICE PRODUCTION 2+1

Objective

To educate advances in production technology of spice crops.

Theory

Spices- current status on area and production, state, national and global scenario of spices, global trade, problems encountered in spices productivity, systems of cultivation, varieties, soil and climate, propagation techniques and nursery management, planting systems and methods, cropping pattern, permanent floor management concepts in mulching and weed management, canopy and root studies under different spice-based cropping systems, shade and basin management, INM practices, irrigation and fertigation techniques, chemical regulation of crop productivity, IPM, clean cultivation strategies, harvesting, Post-harvest and quality management for value added spices, quality standards, GAP and GMP for spices production, quality control and certification. Protected cultivation of high value spice crops. Value addition and byproduct utilization. Pricision farming and organic farming in spice crops. Commodity Boards in spices development.

UNIT I: Pepper and cardamom

UNIT II: Nutmeg, clove, cinnamon and allspice

UNIT III: Turmeric, ginger, garcinia, tamarind and garlic

UNIT IV: Coriander, fenugreek, fennel, cumin and vanilla

UNIT V: Paprika and important herbal spices

Suggested Readings

- Chadha KL. 2001. Hand book of Horticulture. ICAR
- George CK. (Ed.). 1989. Proceedings of First National Seminar on Seed
- Spices. Spices Board, Ministry of Commerce, Govt. of India, Kochi.
- Marsh AC, Moss MK & Murphy EW. 1977. Composition of Food Spices and Herbs, Raw, Processed and Prepared. Agric. Res. Serv. Hand Book 8-2. Washinton DC.
- Parry JW. 1969. Spices and Condiments. Pitman.
- Peter KV. 2001. Hand Book of Herbs and Spices. Vols. I-III. Woodhead Publ. Co., UK & CRC, USA.
- Purseglove JW. 1968. Tropical Crops – Dicotyledons. Longman.
- Purseglove JW, Brown EG, Green CL & Robbins SRJ. 1984. Spices. Vols. I, II. Longman.
- Ridley HM. 1972. Spices. Mac Millan.
- Rosengarten F Jr. 1969. The Book of Spices. Wynnewood; Livingston Publ. Co.
- Ravindran PN. 2001. Monograph on Black Pepper. CRC Press.
- Ravindran PN & Madhusoodanan KJ. 2002. Cardamom, The Genus Elettaria. Series - Medicinal and Aromatic Plants – Industrial Profiles. Routledge, UK.
- Agarwal S, Divkara Sastry EV & Sharma RK. 2001. Seed Spices, Production, Quality and Export. Pointer Publ.
- Shanmugavelu KG, Kumar N & Peter KV. 2002. Production Technology of Spices and Plantation Crops. Agrobios.
- Winton AL & Winton KB. 1931. The Structure and Composition of Food. John Wiley & Sons.
- Yagna Narayan Ayer AK. 1960. Cultivation of Cloves in India. ICAR.
- Nybe EV, Mini Raj N & Peter KV. 2007. Spices. New India Publ. Agency.
- Varmudy V. 2001. Marketing of Spices. Daya Publ. House.

PSMA 603 : ADVANCES IN MEDICINAL AND AROMATIC CROP PRODUCTION TECHNOLOGY 2+1

Objective

To keep abreast with latest developments and trends in production technology of medicinal and aromatic crops.

Theory

UNIT I

Genetic biodiversity of medicinal plants, Conservation networks, Global initiatives on medicinal plants conservation and development, World history on usage of medicinal plants, Preference to natural products, Advanced research in biomedicines, Nutraceuticals and natural drugs, American, European and Asian legislations on plant drugs, Intellectual Property Rights, Patents.

UNIT II

Indian traditional wisdom and Heritage- Indian herbal wealth, Documentations, Databases, Scientific validation, Production Problems of Medicinal and Aromatic plants, Export and import status. WTO scenario - Principles and guidelines for GAP, GCP and GMP in medicinal crops.

UNIT III

Climate, Soil and substrate culture, Improved varieties, Organic production, Nutrition and irrigation requirements, inter culture, mulching, Weed control, Maturity indices and Harvesting, Post-harvest handling, Drying, Processing, Grading, Packing and Storage, Quality standards in medicinal plants, Biotechnological approaches for advances in phyto-chemical extraction technologies, Separation of Bio-molecules, Distillation methods, Essential oil extraction and value addition in aromatic plants, Phytochemicals and drug development.

UNIT IV

Medicinal crops : *Coleus forskohlii,* Glory liliy, Senna, Periwinkle, *Stevia rebaudiana,* Aswagandha, Sarpagandha, *Aloe vera, Dioscorea* sp, *Phyllanthus amarus, Andrographis paniculata,* Medicinal solanum, Isabgol, *Poppy, Digitalis* sp, *Commiphora* sp, *Ipecac, Henbane, Ocimum* sp., *Centella, Bacopa, Saraca indica* and *Bael. Alkaloidal properties of above plants.*

UNIT V

Aromatic crops: Palmarosa, Lemongrass, citronella, vetiver, Geranium, Artemisia, Mentha, Ocimum, Eucalyptus, Rosemary, Thyme, patchouli.

Practical

Identification and documentation- propagation in medicinal crops, Maturity standards, Harvesting and Drying techniques, Processing and grading, Analysis of bio-molecules, Extraction of secondary metabolites, identification and characterization of - secondary metabolites, Essential oils, Visit to commercial medicinal plants field, Visit to GMP phytochemical extraction and value addition unit.

Suggested Readings

- Dharamvir H. 2007. Bioactive Medicinal Plants. Gene Tech Books.
- Farooqi AA, Khan MM & Vasundhara M. 2001. Production Technology of Medicinal and Aromatic Crops. Natural Remedies Pvt. Ltd.
- Farooqi.AA & Sriram AH. 2000. Cultivation Practices for Medicinal and Aromatic Crops. Orient Longman Publ.
- Jain SK. 2000. Medicinal Plants. National Book Trust.
- Khan IA & Khanum A. 2001 Role of Biotechnology in Medicinal and Aromatic Plants. Vol. IX. Vikaaz Publ.
- Panda H. 2002. Medicinal Plants Cultivation and their Uses. Asia Pacific Business Press.
- Prajapati ND, Purohit SS, Sharma AK & Kumar T. 2006. A Hand Book of Medicinal Plants. Agro Bios.
- Ramawat KG & Merillon JM. 2003. BioTechnology – Secondary Metabolites. Oxford & IBH.

PSMA 604 : ADVANCES IN BREEDING OF PLANTATION CROPS AND SPICES 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of plantation crops and spices.

Theory

Evolutionary mechanisms, adaptation and domestication, genetic resources, genetic divergence, cytogenetics, variations and natural selection, types of pollination and fertilization mechanisms, sterility and incompatibility system, recent advances in crop improvement efforts, introduction and selection, chimeras, clonal selections, intergeneric, interspecific and intervarietal hybridization, heterosis breeding, mutation and polyploidy breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, genetics of important traits and their inheritance pattern, molecular and transgenic approaches and other biotechnological tools in improvement of selected spice and plantation crops.

Crops

UNIT I: Coffee and tea
UNIT II: Cashew and cocoa
UNIT III: Rubber, palmyrah and oil palm
UNIT IV: Coconut and arecanut
UNIT V: Pepper and cardamom
UNIT VI: Nutmeg, clove, cinnamon and allspice
UNIT VII: Turmeric, ginger, garcinia, tamarind and garlic
UNIT VIII: Coriander, fenugreek, fennel, cumin and vanilla

Practical

Description and cataloguing of germplasm, pollen viability tests, pollen germination, survey and clonal selection, screening techniques for abiotic stresses, screening and rating for pest, disease and stress resistance in inbreds and hybrids, estimation of quality and processing characters for quality improvement, use of mutagenes and colchicine for inducing mutation and ploidy changes, practices in different methods of breeding and *in vitro* breeding techniques.

Suggested Readings

- Chadha KL. 1998. Advances in Horticulture. Vol. IX, X. Plantation and Spices Crops. Malhotra Publ. House.
- Chadha KL, Ravindran PN & Sahijram L. 2000. Biotechnology in Horticultural and Plantation Crops. Malhotra Publ. House.
- Chadha KL. 2001. Hand book of Horticulture. ICAR.
- Chopra VL & Peter KV. 2002. Handbook of Industrial Crops. Haworth Press, USA &. Panama International Publ. (Indian Ed.).
- Damodaran VK, Vilaschandran T & Valsalakumari PK.1979. Research on Cashew in India. KAU, Trichur.
- George CK. (Ed.). 1989. Proceedings of First National Seminar on Seed Spices. Spices Board, Ministry of Commerce, Govt. of India, Kochi.
- Harver AE. 1962. Modern Coffee Production. Leonard Hoff (Book) Ltd.
- Purseglove JW. 1968. Tropical Crops – Dictyledons. Longman.
- Purseglove JW, Brown EG, Green CL & Robbins SRJ. 1984. Spices. Vols. I, II. Longman.
- Peter KV. 2001-04. Handbook of Herbs and Spices. Vols.I-III.Woodhead Publ. Co., UK & CRC, USA.
- Raj PS & Vidyachandra B. 1981. Review of Work Done on Cashew. UAS Research Series No.6, Bangalore.
- Ravindran PN. 2001. Monograph on Black Pepper. CRC Press.
- Ravindran PN & Madhusoodanan KJ. 2002. Cardamom, The Genus Elettaria Series on Medicinal and Aromatic Plants – Industrial Profiles. Routledge, UK
- Rosengarten F Jr. 1969. The Book of Spices. Wynnewood; Livingston Publ. Co.
- Shanmugavelu KG, Kumar N & Peter KV. 2002. Production Technology of Spices and Plantation Crops. Agrobios.

PSMA 605 : ADVANCES IN BREEDING OF MEDICINAL AND AROMATIC CROPS 2+1

Objective

To update knowledge on the recent research trends in the field of breeding of medicinal and aromatic crops with special emphasis on tropical, subtropical and temperate crops grown in India.

Theory

UNIT I

Origin and evolution of varieties, distribution- Genetic resources, genetic divergence, Plant introduction, selection and domestication - Inheritance of important characters, Genetic mechanisms associated with alkaloids and secondary metabolites.

UNIT II

Methods of breeding suited to seed and vegetative propagated crops. Polyploidy and mutation breeding in the evolution of new varieties, Exploitation of heterosis, utilization of male sterility. Breeding for resistance to pests, diseases, nematodes in medicinal and aromatic crops.

UNIT III

Specific breeding objectives in medicinal and aromatic crops, Genetic bio diversity, Breeding problems and improvements in Senna, Periwinkle, Aswagandha, Isabgol, Sarpagandha, Poppy, Glory lily, *Coleus, Mucuna and Ocimum,* Centella, Bacopa, Dioscorea, Solanum, Andrographis, *Aloe vera*, Phyllanthus, Eucalyptus, Bael, Cinchona.

UNIT IV

Specific breeding objectives in medicinal and aromatic crops, Genetic bio diversity, Breeding problems and improvements in Henbane aromatic grasses, Geranium, Patchouli, Artemisia, Rosemary, Thyme, Sage, Marjoram, Fever few.

UNIT V

Biotechnological approaches for crop improvement of medicinal and aromatic crops.

Practical

Description of crops and cultivars, Cataloguing of species and cultivars, floral biology, selfing and crossing, evaluation of hybrid progenies, Induction of economic, colour mutants, Increased alkaloid content in medicinal crops, high essential oil content in aromatic plants, Physical and chemical mutagens, Induction of polyploidy, Screening of plants for biotic and abiotic stresses and environmental pollution, *in-vitro* breeding in flower crops, medicinal and aromatic crops.

Suggested Readings

- Atal C & Kapoor V. 1992. Cultivation and Utilization of Medicinal and Aromatic Crops. CSIR.
- Chadha KL & Gupta R. 1995. Advances in Horticulture. Vol.XI. Malhot a Publ. House.
- Farooqi AA, Khan MM & Vasundhara M. 2001. Production Technology of Medicinal and Aromatic Crops. Natural Remedies Pvt. Ltd.
- Handa SS & Kaul MK. 1982. Cultivation and Utilization of Medicinal Plants. NISC, CSIR.
- Jain SK. 2000. Medicinal Plants. National Book Trust.
- Julia F & Charters MC. 1997. Major Medicinal Plants – Botany, Cultures and Uses. Thomas Publ.
- Prajapati ND, Purohit SS, Sharma AK & Kumar T. 2006. A Hand book of Medicinal Plants. Agro Bios.
- Thakur RS, Pauri HS & Hussain A. 1989. Major Medicinal Plants of India. CSIR.

PSMA 606 : BIOTECHNOLOGY IN PLANTATION CROPS AND SPICES 1+1

Objective

To teach advances in biotechnology for improvement of plantation crops and spices.

Theory

Crops: Coconut, oil palm, coffee, tea, cocoa, pepper, cardamom, turmeric, ginger, vanilla

UNIT I

In vitro culture methods and molecular approaches for crop improvement in plantation crops and spices, production of haploids, disease elimination in horticultural crops, micro grafting; somoclones and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, *in vitro* production of secondary metabolites.

UNIT II

Protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in vitro* conservation of spices and plantation crops.

UNIT III

In vitro mutation for biotic and abiotic stresses, recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology.

UNIT IV

Quality improvement; improvement for biotic and abiotic stresses; transgenic plants.

UNIT V

Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements, problems and future thrusts in horticultural biotechnology.

Practical

Establishment of axenic explants, callus initiation and multiplication; production of suspension culture, cell and protoplast culture, fusion, regeneration and identification of somatic hybrids and cybrids, Identification of embryonic and non-embryonic calli, development of cell lines; *in vitro* mutant selection for biotic and abiotic stresses, *In vitro* production and characterization of secondary metabolites, isolated microspore culture, isolation and amplification of DNA, gene transfer methods; molecular characterization of transgenic plants.

Suggested Readings

- Bajaj YPS. (Ed.). 1987. Biotechnology in Agriculture and Forestry. Springer.
- Chadha KL, Ravindran PN & Sahijram L. (Eds.). 2000. Biotechnology of Horticulture and Plantation Crops. Malhotra Publ. House.
- Debnath M. 2005. Tools and Techniques of Biotechnology. Pointer Publ.
- Glover MD. 1984. Gene Cloning: The Mechanics of DNA Manipulation. Chapman & Hall.
- Gorden H & Rubsell S. 1960. Harmones and Cell Culture. AB Book Publ.
- Keshavachandran R & Peter KV. 2008. Plant Biotechnology: Tissue Culture and Gene Transfer. Orient & Longman (Universal Press).
- Keshavachandran R, Nazim PA, Girija D. & Peter KV 2007. Recent Trends in Biotechnology of Horticultural Crops. New India Publ. Agency.
- Panopoulas NJ. (Ed.). 1981. Genetic Engineering in Plant Sciences. Praeger Publ.
- Parthasarathy VA., Bose TK, Deka PC, Das P, Mitra SK & Mohanadas S. 2001. Biotechnology of Horticultural Crops. Vols. I-III. Naya Prokash.
- Pierik RLM. 1987. In vitro Culture of Higher Plants. Martinus Nijhoff Publ.
- Prasad S. 1999. Impact of Plant Biotechnology on Horticulture. 2nd Ed. Agro Botanica.
- Sharma R. 2000. Plant Tissue Culture. Campus Books, International.
- Singh BD. 2001. Biotechnology. Kalyani.
- Skoog F & Miller CO. 1957. Chemical Regulation of Growth and Formation in Plant Tissue Culture in vitro. Symp. Soc. Exp. Biol. 11: 118-131.
- Vasil TK, Vasi M, While DNR & Bery HR. 1979. Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture. Plenum Press.
- Williamson R. 1981-86. Genetic Engineering. Vols. I-V. Academic Press.

PSMA 607 : POST-HARVEST PROCESSING AND EXTRACTION IN MEDICINAL AND AROMATIC PLANTS 2+1

Objective

To teach advances in post harvest processing and extraction of economically important medicinal and aromatic crops.

Theory

UNIT I

Post-harvest handling of plant material, preparation of plant material for packaging and extraction. Methods of extraction of secondary metabolites from medicinal crops like sarpagandha, steroid-bearing solanums, ashwagandha, henbane, periwinkle, senna, costus, coleus, etc.

UNIT II

Procedures and equipments used for extraction of active principles. Principles and practices of different types of chromatographs - paper, thin layer, column, gas and high performance liquid chromatography and mass spectroscopy. Preservation of plant extracts and their trade mechanisms.

UNIT III

Harvesting, drying, handling and preparation of different aromatic crops - jasmine, tuberose, oil-bearing rose, scented geranium, patchouli, davana, mints, basils, etc., for essential oil extraction.

UNIT IV

Principles and practices of different types of extraction - distillation, solvent extraction, supercritical fluid extraction, etc. Fine flavour and perfume extraction. Qualitative determination of essential oils. *In vitro* production of biomass and organic extraction of oils. Quality analysis and characterization through chromatographs.

UNIT V

Commercial uses of essential oils, aromatherapy, etc. Commercial utilization of spent material. Storage of essential oils.

Practical

Identification of different economic parts of medicinal and aromatic crops. Preparation of plant material for extraction. Study of different extraction methods. Study of solvents used in extraction of concrete and absolutes. Extraction of crude drugs and essential oils from different medicinal and aromatic crops respectively. Handling of different chromatographs. Quality analysis of essential oils - both physical and chemical, determination of phenol values, acid values, alcohol values, etc. Sensory evaluation of essential oils. Storage studies in essential oils. Visit to commercial extraction and product development units.

Suggested Readings

- Bhattacharjee SK. Amenity Horticulture, Biotechnology and Post-harvest Technology. Vol. V. International Book Periodicals Supply Services.
- Chadha KL (Ed.). 1993-95. Advances in Horticulture. Vols. I-XIII. Malhotra Publ. House.
- Kumar N, Abdul Khader ML, Rangaswamy P & Ikrulappan I. 1994. Spices, Plantation Crops, Medicinal and Aromatic Plants. Rajalakshmi Publ.
- Leo ML Nollet. 1995. Food Analysis by HPLC. Marcel Dekker.
- Masada Y.1986. Analysis of Essential Oil by Gas Chromatograph and Mass Spectrometry. John Wiley & Sons.
- Sadasivam S & Manickam A. 1996. Biochemical Methods. 2nd Ed. New Age International Pvt. Ltd., Bangalore and TNAU; Scientific Publishers (India), Jodhpur.
- Teranishi R, Hornstein I, Issenberg P &. Wick EL. 1971. Flavour Research: Principles and Techniques. Marcel Dekker.
- WHO. 1998. Quality Control Methods for Medicinal Plants Materials. WHO.

PSMA 608 : ENVIRONMENTAL HORTICULTURE 2+1

Objective

To teach advances in environmental management of horticultural crops.

Theory

UNIT I

Environmental complex, interaction of ecological factors in horticultural crop production, interaction of physiographic factors in horticultural crop production. Geo-chemical and hydrological cycles and their impact on ecosystems.

UNIT II

Global warming- carbon trading role of green house gases, elevated CO2 and its impact on productivity of horticultural systems. Habitat ecology, changes in habitats and its impact on horticultural production, Habitat analysis, conservation biology, domestication. Forest ecosystem and its evolution to a hort-ecosystem.

UNIT III

Phytogeography. changes in land use pattern and its impact on horticultural crop production. Natural resource management in horti-systems. Subsistence farming systems of the world, threat and challenges.

UNIT IV

Envoronmental pollution in horti systems, chemicals, fertilizers, etc. Waste management in processing industry, phytoremediation.Alternate farming systems, horticultural therapy Environmental policy& legislation in India, International treatise and Summit, Biodiversity Board, Act, etc.

Practical

Phyto-sociological analysis, assessment of plant associations in natural and domestic systems, productivity assessment of various ecosystems, analysis and assessment of various phytogeographic zones, assessment of land use changes and its impact on horticultural systems, assessment of biodiversity, pesticide residue analysis in horticultural produce.

Suggested Readings

- Ashby M. 1973. Introduction to Plant Ecology. MacMillan Press.
- CSIR. 1971. The Wealth of India. Vols. A-Z. CSIR.
- Daubenmire RF. 1959. Plants and Environment. Wiley Eastern.
- Fall. 2001. Tolerance of Landscape Plants to Recycle Water Irrigation. UC and ANR Publ.
- Mathew IP & Karikari SK. 1990 Horticulture Principles and Practices. MacMillan Intermediate Agricultural Series.
- Prasad S & Kumar U. 2003. Principles of Horticulture. Agrobios.
- Sasikumar B, Krishna Murthy B, Rama.J, Ravindran PN & Peter KV. (Eds.). 1999. Biodiversity Conservation and Utilization of Spices, Medicinal and Aromatic Plants. IISR, Calicut.
- Singh PP. 2006. Perspectives in Plant Ecology and Environmental Biology. Scientific Publ.

POST HARVEST TECHNOLOGY

PHT 501 : PRINCIPLES OF POST- HARVEST MANAGEMENT FOR PRISHABLE HORTICULTURAL PRODUCE 1+1

Structure and composition of fruits and vegetable; Role of fruits and vegetables including mushrooms in nutritional security. Maturity indices, harvesting, grading methods; Physicochemical change during ripening and storage; physiological processes - respiration, transpiration and ethylene biosynthesis and their influence on storage quality and senescence; Pre- storage treatments for quality retention and regulation of ripening using chemicals, Skin coatings, Growth regulators, fungicides; Irradiation; Packages and packing house operations; Storage systems. Pre - cooling, Low temperature controlled Atmosphere (CA), Modified Atmosphere (MA) and Hypobaric storage; On- farm storage; Storage requirements of different fruit, vegetables and mushrooms; Processing of mushrooms, storage disorders; Spoilage and their control; Transportation, marketing and export requirement.

Practical

Determination of maturity indices for fruits and vegetables; Postharvest treatments with waxes, growth regulators; fungicides and their effect on storage behaviors; Storage methods and quality evaluation during storage; Studies on storage disorders; Determination of respiration rates, ethylene evolution, practices in packaging; Visit to cold storage and other institution engaged in post harvest handling and marketing of fruit, vegetables and mushrooms.

Suggested Books:

- Agrawal, R.K. and C.L.Jandaik, 1986.Mushroom Cultivation in India. Official Publication of Indian Mushroom Growers Association, Solan,H.P.
- Burton, W.G. (1982).Post harvest technology of fruits and vegetables. Blackwell Science Ltd., Oxford, U.K.
- Chadha.K.L.and O.P.Pareek 1993.(Eds.).Advances in Horticulture. Vol 1-4. Malhotra Publishing House. New Delhi.
- Chadha, K.L and G. Kallo (Eds.).1993.Advances of Horticulture. Vol.5-6. Malhotra Publishing House. New Delhi.

PHT 502 : FUNDAMENTALS OF PROCESSING OF FRUIT AND VEGETABLES 1+1

Importance of processing in horticulture development. History of preservation. Nutritive value of processed fruits and vegetables. Role of micro- organisms, enzymes and water activity in

preservation, principles and methods of preservation by heat, chemical, drying, radiation, freezing and fermentation. Modern methods of drying and dehydration. Drying equipment. Intermediate moisture foods. Role of fermentation for different fermented products. Methods of preparation of confectionery and tomato products. Canning of fruits and vegetables. Preserving of fruit juices, beverages and concentrates. Fundamentals of freezing of fruits and vegetables. Packaging and storage of processed fruit and vegetable products Management of different processed wastes. Food processing and nutrition. Importance of hygiene and sanitation. Food laws. hazard analysis and critical control points (HACCP), TQM, GMP, Investment analysis.

Practical

Blanching and its effect on enzymes. Preparation of different products as per food laws and regulations. Extraction of pectin and its evaluation. Dehydration, canning, freezing, chemical preservation and fermentation. Evaluation of food nutrients. Visit to fruit and vegetable processing plants. HACCP.

Suggested Books:

- Cruss, W.V.1958.Commercial Fruit and Vegetable Products.Mc Grew Hill Book Company, Inc., New York.Desrossier, N.W.1970.The Technology of food preservation.3rd Ed; AVI Publishing Co. Westport.
- Lal,G.,G.S.Siddappa and G.L.Tondon.1986.Preservation of Fruits and Vegetables.ICAR,,New Delhi.
- Luh, B.S. and J.G.Woodroof.1975.Commercial Vegetable Processing.AVI Pub.Co., Westport.

PHT 503 : LABORATORY ANALYSIS AND QUALITY ASSURANCE TECHNIQUES OF FRESHAND PROCESED HORTICULTURAL PRODUCE 1+1

Objectives and importance; Functions and methods of quality assessment of fruit and vegetable products; Specification of finished products; Food laws and regulation Acts viz., F.P.O.,PFA, Codex Alimentarius etc. Principles and techniques of analysis of proximate composition of fruit and vegetables and their products; Interpretation of laboratory analysis in relation to product quality; Chemical and physical nature of food additives, sensory evaluation of food , estimation of food additives, colour evaluation with respect to the value, hue and chrome; Texture, tenderness and consistency evaluation; Laboratory examinations of canned products - drained weight, vacuum/pressure, head space, water activity, pH, vitamins and microbial quality. Sampling techniques, Statistical Quality Control, Modeling, Total quality management, HACCP. Microbial spoilage of fresh and processed horticultural produce.

Practical

Demonstration of measurement of vacuum/pressure, head space, field weight, drained weight, cut-out analysis and chemical additives; Estimation of chemical constituents like 0 Brix, vitamins, etc.; Evaluation of typical products according to food laws. HACCP exercise, problem solving techniques, Group discussion.

Suggested Books:

- AOAC 1970.Official Methods of Analysis,Washington DC.
- Kramer,A. and B.A.Jurigg,1970.Quality control for the food Industry.AVI pub.Co.,Westport.
- Plummer,D.T.1990.An introduction to practical biochemistry.Tata Mc Graw Hill Publication co;New Delhi.
- Ranganna,S.1986.handbook of Analysis and Quality control for Fruit and Vegetable products. Tata Mc Graw Hill Publication co; New Delhi.

PHT:504 : TECHNIQUES FOR SENSORY ANALYSIS OF PROCESSED PRODUCE 1+1

Importance and methods for sensory analysis. Panel selection and training. Requirements of sensory evaluation laboratory. Analysis for appearance, taste, aroma, colour, texture and flavour. Designing of experiments. Handling and interpretation of data. Role of sensory evaluation in product optimization. Sensory analysis for consumer evaluation.

Practical

Procedure for sensory analysis. Identification of basic taste, odour, texture and colour. Determination of the threshold activity. Hedonic testing. Testing of individual and overall quality by ranking. Selection of panel. Optimising a product by sensory analysis.

Suggested Books:

- Amerine, M.A.1965.Methods in Sensory Analysis.AVI Pub.Co., Westport.
- O'Mahony, 1985.Sensory Analysis of Foods: Statistical Methods. Marcel Dekker, Basal.
- Piggot, J.R.1985.Sensory Analysis.Elsevier, Netherlands

PHT 505 : PRE-HARVEST PRACTICES AFFECTING POST- HARVEST LIFE OF PERISHABLE HORTICULTURAL PRODUCE **2+0**

Influence of pre-harvest crop management viz. Fertigation, irrigation, growth regulators, environmental, varietals and cultural operation on post harvest quality of horticultural produces. Effect of organic farming and eco - friendly crops management on quality of horticultural produce.

Suggested Books:

- Bose, T.K. and S.K.Mitra (Eds.).1996.Fruits: Tropical and sub-tropical.Nayaprokash Pub., Calcutta.
- Pantastico, Er.B. (Eds.) 1975.Postharvest physiology, handling and Utilization of Tropical and Sub-tropical Fruits and Vegetables.AVI Pub. Co. Westport.
- Ryall, A.L.and W.T.Pentzer, 1982.Handling, Transportation and Storage of Fruits and VegetablesVol.1, Vegetables and Melons, AVI Pub.Co., Westport.
- Ryall, A.L.and W.T.Pentzer, 1982.Handling, Transportation and Storage of Fruits and VegetablesVol.2, Fruits and Tree Nuts. AVI Pub.Co.,Westport

PHT 506 : PRINCIPLES OF POST-HARVEST MANAGEMENT OF SPICES AND PLANTATION CROPS **1+1**

Role of plantation crops and spice on economic upliftment of society. Importance and scope; Nature, structure and composition of plantation crops and spices; Maturity indices and harvesting; physiochemical changes after harvest and during postharvest handling, marketing and storage. Quality assurance methods; Packages and packing house operations; Methods of storage precooking, refrigerated, controlled atmosphere, modified atmosphere and hypobaric storage; Storage disorders; Spoilage and its control; Transportation, marketing and storage requirement.

Practical

Harvesting indices and harvesting methods for different plantation crops and spice crops; postharvest treatments; Packages and Packing; Storage methods and their influence on quality; Study of storage disorders; Visit to cold storage and other institutions engaged in postharvest handling and marketing of plantation crops and spices.

Suggested Books:

- Anonymous, 1985.Rubber and Its Cultivation.the Rubber Board of India, Kottayam.
- Bavappa, K.V.A.1992.Monograph on Aracenut.CPCRI, Kasargod.
- Chadha K.L.and P.Rethinam (Eds.) 1994.Advances in Horticulture.Vol. 9-10.malhotra Publishing House. New Delhi.
- Patel, I.S.1938.The coconut.A Monograph.Govt.Press, Mardas.
- The Oil Palm IInd Ed. By C.W.S.Hartley (1977) chapter. 13 & 14

PHT 507 : PRINCIPLES OF POST-HARVEST MANAGEMENT OF ORNAMENTAL, MEDICINAL AND AROMATIC PLANTS **1+1**

Importance and scope; Post harvest physiological and biochemical changers in ornamental, aromatic and medicinal plants; Maturity selection at harvest; Harvesting, grading, bunching of cut flowers; Post-harvest handling of aromatic and medicinal plants; Factors affecting cut flower longevity; Pre-treatments for extending vase life of cut flowers -pre- cooling, use of preservative solution and other chemicals; Recommended storage techniques and condition for ornamental, aromatic and medicinal plants; Importance of cold chain; Storage disorders

and their control; preparation of cut flowers for marketing; Transportation, marketing and export requirement.

Practical

Harvesting indices and equipment; Grading, sorting, cleaning and preparation for marketing; Pre- storage/ packaging treatments to enhance shelf life; Packages and packaging methods; Storage methods and their effect on quality; Storage disorders; Visit to cold storage and other institutions.

Suggested Books:

- Bose, T.K.and P.Yadav. (Eds.) 1989.Commercial Flowers.Naya prokash, Calcutta.
- Bose,T.K. and S.K. Bhattarchjee.1980.Orchids of India. Naya prokash, Calcutta.
- Chadha, K.L. and B.Choudhry.1986.ornamental Horticulture in india.ICAR, New Delhi.
- Chadha,K.L. and S.K. Bhattarchjee (Eds.)1995.advances in horticulture. Vol.12. Part-III. Malhotra Publishing House, New Delhi.

PHT 508 : PROCESSING OF PLANTATION CROPS, SPICES, MEDICINAL AND AROMATIC PLANTS 1+1

Classification of spices and medicinal plants. Commercial uses of spices. Processing of major spices: capsicum, cardamom, ginger, pepper and turmeric, minor spices - coriander, clove, nutmeg, all spice, leafy spices- bay, mint, thyme and curry leaves. Seed spices - fenugreek, mustard and sesame. Dioscorea, liquorice, coleus, ashwagandha, tulsi, isabgol, brahmi. Different methods of drying and storage. Influence of temperature and time combination on active principles, extraction and analysis of active principle using TLC and HPLC technology of essential oil extraction. Distillation, solvent extraction, super critical fluid extraction from davana, mints, rosemary, rose, citronella, lavender, jasmine, fennel dill. Identification of different odour factors with GLC/GC- MS in essential oil. Processing of plantation produce of plantation crops, viz. Coconut, oilpalm, Cocoa, tea, coffee, rubber etc for value added products.

Practical

Extraction of active ingredients from different spices and herbs. Physico- chemical and sensory evaluation of oils and oleoresin.

Suggested Books:

- Anonymous.Indian Herbal Pharmacopia-AJoint publications of Regional research laboratory, Jammu Tawi and India manufacture Association, Mumbai.
- Chadha, K.L.and Rajendra Gupta (Eds.) 1995.Advances in Horticulture.Vol. 11. Medicinal and Aromatic Plants.Malhotra Publishing house, New Delhi.
- Guenlther, E.1949.The Essential Oils.D.vanNostrand Co., Demonstration.
- Masada, Yoshiro.1986.Analysis of Essential Oil by gas Chromatography and mass Spectrometry.A Halsted Press Book, John Wiley &Sons, New Delhi.

PHT 509 : PACKAGINGS FOR PERISHABLE HORTICULTURAL PRODUCE 1+1

Importance, package design and package type: bags, wooven baskets, field containers, plastic crates, palletization, utilization. Fiberboard boxes, nature of packaging material, MAP, cooling of produce in package dimension. storage, package testing, consumer packaging.

Practical

Survey of packages, effect of packaging on storage life and quality, pre-cooling, Map, consumer packaging, testing of package and packaging materials.

Suggested Books:

- Pantastico, Er.B. (Ed.), 1975.Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables.AVI Pub.Co.,Westport.
- Ryall,A.L. and W.J. Lipton,1979.handling,Trasportation and Storage of Fruits and Vegetables,Vol.1,vegetables and Melons,AVI Pub. Co.Westport.
- Ryall, A.l. and W.T.Pentzer, 1982.Handling, Transportation and Storage of Fruits and Vegetables, Vol.1, vegetables and Melons, AVI Pub. Co.Westport.
- Thompson, A.k.1996.Post-harvest technology of Fruits and Vegetables. Blackwell Sci.Ltd., Oxford.

PHT 510 : PACKAGING TECHNOLOGY OF PROCESSED HORTICULTURAL PRODUCE 2+1

Introduction, history, evolution, function and scope of packaging. Packaging materials- paper based packaging, plastic, glass containers, metal packaging, natural material. Graphics and package design. Packaging machinery - bottling, canning operations, wrapping, operations, bag manufacturing, filling and closing, cartoning, fill and seal machines, and labeling. Organization of packaging lines. Packaging for physical distribution. Packaging needs for marketing of heat- processed, refrigerated and frozen foods, and fruit juices. Bulk Packaging.Specifications and quality control. Future thrusts and scope of packaging technology.

Practical

Demonstration of different packaging systems. Evaluation of different packaging materials, Exercises in packing of fresh fruit and vegetables and their products. Visit to package fabrication industries. Visit to supermarkets for familiarization with existing packages and innovative trends.

Suggested Books:

- Pantastico, Er.B. (Ed.), 1975.Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables.AVI Pub.Co.,Westport.
- Ryall,A.L. and W.J. Lipton,1979.handling,Trasportation and Storage of Fruits and Vegetables,Vol.1,vegetables and Melons,AVI Pub. Co.Westport.
- Ryall, A.l. and W.T.Pentzer, 1982.Handling, Transportation and Storage of Fruits and Vegetables, Vol.1, vegetables and Melons, AVI Pub. Co.Westport.
- Thompson, A.k.1996.Post-harvest technology of Fruits and Vegetables. Blackwell Sci.Ltd., Oxford.

PHT 511 : PROCESS ENGINEERING IN HORTICULTURAL CROPS 2+1

Importance and scope, conveying and elevating equipment, physical and thermal properties of horticultural commodities; Rheological and textural properties; Heating processes; Thermal process calculation; Heating equipment applied to processing viz., jacketed pan, plate and tubular heat exchanger; Evaporator in food industries, multiple effect and multistage evaporator, size reduction; Features and design specification; Planning for domestic as well as commercial storage and processing facilities; Drying equipment; Classification of filtration equipment and outline; Equipment in cannery; Kinetics of growth and enzyme reactions; Fermentation; Equipment and product recovery; Discharge of industrial waste; Freezing equipment. Unit operations of processing.

Practical

Handling of harvesting equipment; Determination of physical and thermal properties, thermal process calculations; Particle size analysis; Storage structure design; Numerical problems in freezing, drying, conveying and calculations pertaining to texture and rheology; Handling of heating equipment, pulper, juice extractor, deaerator, juice filters; Processing industries waste treatment; Working of a canning unit; Visit to commercial processing units and storage units.

Suggested Books:

- Earle, R.L.1966.unit Operation and Food Processing.Pergamon Press, Oxford, U.K.
- Paleg and Bagley.1987.Physical Properties of Foods.AVI Pub.Co.,Westport.
- Stumbo, 1965.Thermobacteriology in Food Processing. Academic Press, New York

PHT 512 : IN - PLANTS TRAINING (NON CREDIT COMPULSORY COURSE)

The student will be attached to a commercial ware-house, packing yard or processing plants where he will receive practical training in various aspects of post- harvest handling viz., harvesting, sorting and grading, pre- storage treatments, packing, storing, transport, marketing, processing etc. In the processing plants, he will attend to various unit operations involved in the processing of different fruit and vegetable products. He will maintain daily production schedule of finished products and utilisation of raw material. He will be required to submit a detailed report of his training along with a layout plan of the unit attended by him.

PHT 601 : ADVANCES IN POST - HARVEST MANAGEMENT OF FRESH HORTICULTURAL PRODUCE **2+0**

Respiration and ripening, climacteric phenomenon, ethylene factor, ripening process. Biosynthesis of ethylene and its regulation. Ethylene action and metabolism. Physiology of CA and MA packaging and storage. Gas exchange. Enzymes and textural changes during ripening. Molecular biology of ripening. Polyphenol oxidases, peroxidase and catalyses in fruits and vegetables. Anthocyanins and other pigments in fruits and vegetables. Active packaging, Irridiation technology, vapour heat treatment technology etc.

Suggested Books:

- Pantastico, Er.B. (Eds.) 1975.Postharvest physiology, handling and Utilization of Tropical and Sub-tropical Fruits and Vegetables.AVI Pub. Co. Westport.
- Ryall, A.L.and W.T.Pentzer, 1982.Handling, Transportation and Storage of Fruits and VegetablesVol.1, Vegetables and Melons, AVI Pub.Co., Westport.
- Ryall, A.L.and W.T.Pentzer, 1982.Handling, Transportation and Storage of Fruits and VegetablesVol.2, Fruits and Tree Nuts. AVI Pub.Co.,Westport

PHT 602 : IN LABORATORY TECHNIQUES AND RESEARCH METHODOLOGY IN POST HARVEST TECHNOLOGY **1+2**

Advances in techniques of food analysis for carbohydrate, organic acids, vitamins, polyphenols, flavonoids, minerals, anthocyanins, enzymes; Rheological techniques and instrumentation used in food industry; Determination of browning and associated reaction in processed foods and their implication; Pesticide residues; Sprout inhibitors; principles of chromatography (GC, GC-MS, HPLC), spectrophotometer (Atomic absorption spectrophotometer, ICAP spectrophotometer), NMR, ESR, amino acid analyser, flame photometry, electrophoresis, colour measurements in foods, IRGA, Radio - isotopic techniques.

Practical

Handling and working of food analysis equipment viz., GC, HPLC, spectrophotometer (AAS, ICAP spectrophotometer), NMR, flame photometer, electrophoresis; Energy calculation, Sample calculations, Rheological behavior of different foods.

Suggested Books:

- Kramer,A. and B.A.Jurigg,1983.Quality control for the food Industry.AVI pub.Co.,Westport.
- Plummer,D.T.1990.An Introduction to practical biochemistry.Tata Mc Graw Hill Publication co;New Delhi.
- Ranganna,S.1986.Handbook of Analysis and Quality control for Fruit and Vegetable products. Tata Mc Graw Hill Publication co; New Delhi.

PHT 603 : ADVANCES IN PROCESSING TECHNOLOGY OF HORTICULTURAL CROPS **3+0**

World food problems and preservation; Cryobiology; Recent trends in thermal processing; Ultra high temperature processing; Aseptic packaging; Microwave energy in processing; Use of ultrasonic waves in processing; Membrane technology; High pressure technology; Irradiation; Extrusion cooking; Intermediate moisture foods; Concentrated foods; Split processing; Developments in food additives; Natural colourants; Flavour stabilization and encapsulation; Enzymes in food processing; Immobilization of enzymes and microbes; Trends in food fermentation; Biotechnology in post-harvest management. Aerated foods; Food fortification; genetically modified foods. Probiotics; Bacteriocins; Health and formulated foods and fast food technology; Problems associated with new technologies.

Suggested Books:

- Earle, R.L.1966.unit Operation and Food Processing.Pergamon Press, Oxford, U.K.
- Paleg and Bagley.1987.Physical Properties of Foods.AVI Pub.Co.,Westport.
- Stumbo, 1965.Thermobacteriology in Food Processing. Academic Press, New York

PHT 604 : PACKING HOUSE OPERATIONS AND TRANSPORTION OF FRESH HORTICULTURAL PRODUCE **2+0**

Quality, losses and production factors, harvest maturity and methods, post harvest treatments, pack house operations - loading and unloading of produce, pre-treatments, grading, post-grading treatments, packaging methods.

Suggested Books:

- Pantastico, Er.B. (Ed.), 1975.Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables.AVI Pub.Co.,Westport.
- Ryall,A.L. and W.J. Lipton,1979.handling,Trasportation and Storage of Fruits and Vegetables,Vol.1,vegetables and Melons,AVI Pub. Co.Westport.
- Ryall, A.l. and W.T.Pentzer, 1982.Handling, Transportation and Storage of Fruits and Vegetables, Vol.1, vegetables and Melons, AVI Pub. Co.Westport.
- Thompson, A.k.1996.Post-harvest technology of Fruits and Vegetables. Blackwell Sci.Ltd., Oxford.

PHT 605 : COMMERCIAL ASPECTS OF POST- HARVEST TECHNOLOGY OF HORTICULTURAL PRODUCE **2+0**

Design and layout of fruit and vegetable processing industry; packing station for handling of fresh commodities, cool chain; marketing channels, import- export trade; investment analysis; concept of marketing. List of equipments.

Suggested Books:

- Chadha, K.L.and Others.(Eds.)1993-1995.Advances in Horticulture.Vol 1-3.Malhotra Publishing house.New Delhi.
- lal,G.,G.S. Siddappa and G.L. Tondon,1986.Preservation of Fruits and Vegetables.ICAR,New Delhi.
- Luh B.S.and J.G.Woodroof,1982.Commercial Vegetable Processing.AVI Publ.Co.,Westport.
- J.G.Woodroof,and Luh B.S.1982.Commercial Fruit Processing.AVI Publ.Co.,Westport.

PHT 606 : DEHYDATION TECHNOLOGY OF HORTICULTURAL PRODUCE **2+1**

Introduction - principles, importance, history and scope of drying. Equilibrium relative humidity (ERH), water activity and food stability. Methods of drying (foam mat, osmotic and reverse osmotic drying, Freeze drying, accelerated freeze drying, dehydro- freezing) and equipment. Home scale and commercial drying of perishables including flowers. Fruit juice concentration and powders. Drying of commercial fruits and vegetables. Effect of drying on product quality and storability. FPO and ISI specifications for dried products.

Practical

Drying of some important fruits and vegetables. Drying rates and dehydration rations. Determination of water activity. Evaluation of dried products. Visit to dehydration industries.

Suggested Books:

- Cruss, W.V. 1958. Commercial Fruit and Vegetable Products.Mc Graw Hill Book Company,Inc.,New York.
- Lal, G., G.S. Siddappa and G.L. Tondon, 1986. Preservation of Fruits and Vegetables.ICAR,New Delhi.
- Luh B.S. and J.G. Woodroof, 1982. Commercial Vegetable Processing. AVI Publ.Co.,Westport.
- J.G.Woodroof, and Luh B.S. 1982. Commercial Fruit Processing. AVI Publ.Co.,Westport

PHT 607 : FREEZING TECHNOLOGY OF HORTICULTURAL PRODUCE **2+1**

Introduction, cryobiology, principles of freezing, equipment, methods of freezing. IQF, quality of thawed products, spoilage of frozen products, Numerical problems on specific food freezing. Effect of freezing on nutritive value. Quality control , sensory evaluation, cryogenic preservation of products. Problems associated with food freezing.

Practical

Slow and fast freezing of fruits/ vegetables. Quality of frozen foods. Numerical problems. Visit to a food freezing unit.

Suggested Books:

- Tressler,D.K.,W.B.van Arsdel and M.J. Copley,1968. Freezing Preservation of Foods. Vol. I-IV.AVI Pub. Co.,Westport.

PHT 608 : FRUIT AND VEGETABLE FERMENTATION TECHNOLOGY 2+1

Introduction-definition, history, importance and scope. Role of fermentation in preservation. Nutritive value of wines, beers, distilled liquors and fermented vegetables. Yeast and its requirements. General methods of fermentation. Types and methods of preparation of wines, beer, cider, vermouth, brandy and their role in human health. Vinegar and lactic acid fermentation and their uses. Fermentation technology for waste treatment. Equipment and machinery used in a brewery or alcohol manufacturing plant. Quality attributes of alcoholic and other fermented products. Spoilage of fermented products and their control measures. Biochemical changes caused by fermentation and factors affecting fermentation types.

Practical

Isolation and culture of yeast and lactic acid micro-flora. Preparation of wines, brandy, cider and fermented pickles. Analysis for alcohol, acidity (total and volatile), TSS, pH, sugars and sensory attributes.

Suggested Books:

- Amerine et al.1980.technology of Wine Making.AVI Publ.Co.,Westport.
- Potter,N.1978.Food Science.AVI Publ.Co.,Westport.
- Reed,G.1999.Prescott and Dunn's Industrial Microbilogy.CBS Publ. and Distributers.new Delhi.
- Vine,R.P.1981.Commercial wine Making.AVI Publ.Co.Inc.Westport.

PHT 609 : WASTE MANAGEMENT FROM HORTICULTURE PROCESSING INDUSTRIES 2+1

Need for waste management. Waste Characteristics - sampling methods, analysis, and standards for waste discharge. Survey and nature of waste from processing industry. Methods for waste and waste water reduction. In plants modifications and innovative processes. Recovery of useful materials from waste viz., colour, essence, pectin, oils etc. Utilization of waste - new products, animal feed, and single cell protein. Technology of treatments of waste effluent from fruit and vegetable industries. Immobilized bioreactor in waste treatment. Anaerobic bioreactor and energy production. Economics of effluent management.

Practical

Analysis of waster. Waste utilization from recovery of useful material. Commercial products from waste. Visit to fruit and vegetable industries equipped with waste disposal system.

Suggested Books:

- Green and Kumar,1979.Waste Management Technology.AVI Publ.Co.,Westport.
- Joshi,V.K.and A.pandey,1999.Biotechnology:Food Fermentation.Vols.I & II,educational Publisher and Distrivbuter,new delhi.
- Pandey,A.1998.Advances in Biotechnology:Educational Publisher and Distributor,New Delhi.
- Salunkhe,D.K. and S.S.kadam.1995.A handbook of fruit Science.Marcel dekker,Basal.