UNIVERSITY OF HORTICULTURAL SCIENCES
BAGALKOT

COURSE SYLLABUS
FOR
Ph.D DEGREE PROGRAMME

(Revised Syllabus as per ICAR guidelines)

SEMESTER SYSTEM

2016-17

OFFICE THE DEAN POSTGRADUATE STUDIES
UNIVERSITY OF HORTICULTURAL SCIENCES
BAGALKOT - 587 104

UNIVERSITY OF HORTICULTURAL SCIENCES
BAGALKOT

POSTGRADUATE PROGRAMMES

Ph.D Degree Programme

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COURSE AND CURRICULUM OF DOCTORAL DEGREE PROGRAMMES

CREDIT REQUIREMENTS FOR DOCTORAL PROGRAMMES

Sl. No.	Course Work	Doctoral Degree Programme
1.	Major subject a. Core Courses b. Optional Courses	 15 08
2.	Supporting Courses	05
3.	Non-credit compulsory Courses (if not done at M.Sc. level)	02*
4.	Non-credit compulsory Study Tour (PGS 607, 0+1)	01*
5.	Seminar	04
6.	Qualifying Examination	04
7.	Research	39**
	Total	75+3*

** 6 Credits of research out of 39 credits will be graded by the Advisory Committeee at the time of final viva-voce examination on 10 point scale.

Ph. D- FLORICULTURE AND LANDSCAPE ARCHITECTURE

Course No.	Course No.	Credits
FLA-601	Advances in flower production technology	2+1
FLA-602	Advances in landscape architecture	1+2
FLA-603	Advances in protected and precision floriculture	2+1
FLA-604	Advances in breeding of flower crops	2+1
FLA-605	Advances in biochemistry and biotechnology of flowers	2+1
	TOTAL	15

Ph. D- FLORICULTURE AND LANDSCAPE ARCHITECTURE

Course No.	Course No.	Credits
FLA-606	Flori-business and its management	2+0
FLA-607	Advances in Rose, Anthurium and Orchid production under cover	2+1
FLA-608	Planting material and seed production in flowercrops	1+1
FLA-609	Advances in post harvest handling and value addition in ornamental crops	2+1
	TOTAL	10

Ph. D- FLORICULTURE AND LANDSCAPE ARCHITECTURE

CORE COURSES:

FLA- 601 ADVANCES IN FLOWER PRODUCTION TECHNOLOGY (2+1)

Theory : 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.

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 CO_2 on growth and flowering; regulation for quality flowers.

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.

Crop specific production practices – Rose, Anthurium, Orchids, Carnation, Gladioli, Gerbera, Liliums, Heliconia, Bird of Paradise, Jasmine, Marigold, Tuberose, Crossandra, China aster, Chrysanthemum, Lotus, Tulip and Dahlia.

Floral oil industry, floral concrete production, extraction methods, recent advances.

Practical : Varietal wealth in flower crops; Greenhouse management; Soil decontamination techniques; Micro-irrigation systems; 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 Reference:

Bose T K., L.P. Yadav, Commercial Flower, 1989
Surendra Prasad and Upadesh Kumar., 1998. Commercial floriculture
Bose T K., L.P. Yadav, P.Das and V A Parthasarathy. Commercial Flower, 2002: Vol.1 and Vol.2
S.K. Bhattacharjee and L.C. De., 2003. Advanced Commercial floriculture

FLA 602 ADVANCES IN LANDSCAPE ARCHITECTURE (1+2)

Theory : Commercial landscape gardening- History, Plant identification and ecology, Materials of garden design, Design making by different garden styles and types.

Expenses to model landscaping units of all category, Creativity and communication skills for landscape architect, Way of designing a commercial landscape project.

Assessing site and plants adaptability for different locations, Landscape engineering (Topographical survey and designing concept), special techniques in garden landscaping (Burlaping, water-scaping, hard-scaping, lawn making, topiary styles specializing, bio-aesthetic 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 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, water-scaping, hard-scaping, lawn making, topiary styles specializing, bio-aesthetic 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 pollen 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 Reference:

Bhattacharjee, S.K. 2004, Landscape Gardening and Design with Plants. Aavishkar Publishers and Distributors, Jaipur, India.

Bose, T.K., Chowdhury, B. and Sharma, S.P..2001. Tropical Garden plants in colour, Horticulture and Allied Publishers, Kolkata.

Ervin, S. and Hasbrouck, H., 2001. Landscape modeling: Digital Techniques for Landscape Visualization, , , Mc Graw-Hill, New York.

M. Ashraf., A Hand book of landscape- Gardening and environment:, Agribusiness publishers, Jodhpur

Rajesh Shrivastsava., Fundamentals of garden designing.

Randhawa, G.S. and Mukopadhyay, A. 1998., Floriculture in India,1998, Allied Publishers Limited, New Delhi.

Root James, B., Nde., 1985. Fundamentals of Landscaping and Site Planning, AVI, Publishing company, Inc., Connecticut, USA.

Sabina, G.T. and Peter, K.V., 2008. Ornamental Plants for Gardens. New India Publ. Agency, New Delhi.

Tickoo, A. 2004. Auto CAD Problem Solving Approach, ISBN 1-4018-51339

Ronal,T., Biondo, Charles, B., Schroeder Imer. Introduction to landscaping, design, construction and maintenance.

Bose, T.K. et al., .Garden plants in colour,

Roy, R.K., 2013, Fundamental of garden designing, New India publishing age.

FLA-603 ADVANCES IN PROTECTED AND PRECISION FLORICULTURE (2+1)

Theory : Prospects of protected floriculture in India, growing structures, basic considerations in establishment and operation of green houses, functioning and maintenance.

Environmental control systems in greenhouse, containers, substrate culture, soil decontamination techniques.

Water and nutrient management, crop regulation, special horticultural practices under protected cultivation of rose, chrysanthemum, carnation, orchids, anthurium, gerbera, liliums, cut foliage; Harvest indices – harvesting, Post harvest handling, marketing, export.

Precision floriculture: Principles and concepts, Enabling technologies of precision farming, GPS, GIS, Remote sensing, sensors.

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 Reference:

Tiwari G N., and R.K. Goyal. 1998. Greenhouse Technology

Prasad, S and U. Kumar. 2001. Greenhouse management for Horticultural Crops

Tiwari G N., Greenhouse Technology for controlled environment

Jitendra Singh, S K. Jain, L.K. Dashora and B.S. Chundawat. Precision Farming in Horticulture

S.C. Swain. Precision Farming in Horticulture- Approaches and stratergies.

Tiwari G.N. Green house technology fundamentals designs modeling and application

Singh and Brahma. Advances in protected cultivation Bose T K., Commercial protected floriculture

FLA-604 ADVANCES IN BREEDING OF FLOWER CROPS (2+1)

Theory : 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.

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, self incompatibility problems and in vitro breeding.

Breeding for resistance to pests, diseases, nematodes and other biotic and abiotic stresses in flower crops.

Specific breeding problems and achievements made in rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, arnati on, gerbera, gladioli, orchids and anthurium.

Specific breeding problems and achievements made in China aster, petunia, liliums, heliconia, bird of paradise, hibiscus and bougainvillea.

Suggested Reference:

Bose T K., L.P. Yadav, P.Das and V A Parthasarathy. Commercial Flower, 2002: Vol.1 and Vol.2

Pal, B.P., 1991. The rose in India

S.K. Bhattacharjee and L.C. De., 2003. Advanced Commercial floriculture

N.Kumar. Breeding of Horticultural Crops: Principles and Practices
Varnangamudi., Advances in seed science and technology (vol:7) flower seed production
L C De, Bhattacharjee S., Ornamental Crop Breeding
Thirugnanakumar S., Basics of mutation breeding
Datta S K., Ornamental Plants: Role of mutation
Singh A K., Breeding & Biotechnology of flowers

FLA-605 ADVANCES IN BIOCHEMISTRY AND BIOTECHNOLOGY OF FLOWERS (2+1)

Theory : 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).

Recent trends- Extraction of bio-colours and their value addition, uses in food and textile industries. Biochemistry of post harvest management of cut flowers.

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.

In vitro lines for biotic and abiotic stress – Meristem culture for disease elimination, production of haploids through anther and culture – embryo and ovule culture, micro-grafting, 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.

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.

Gene cloning, genetic engineering: vectors and methods of transformation – electroporation, particle bombardment, Agrobacterium mediated, transgenic plants in flower crops, isolation of DNA, RNA, quantification, Polymerase Chain Reaction for amplification; AGE & PAGE techniques; identification of molecular markers.

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 made through 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 Reference:

Teixeira J.A., Floriculture, Ornamental and plant biotechnology (5 vol. set)

Purohit, S.S. and Rajan, R., Flowering physiology, biochemical and molecular aspects

Saini R S. Laboratory mannual of analytical techniques in Horticulture

Kumar.U. Handbook of Nanotechnology

Geneve, R,L., Biotechnology of Ornamental Plants

Singh A K., Breeding & Biotechnology of flowers

Datta,S.K.and D. Chakraburty., Floriculture: Role of Tissue culture and molecular technique.

OPTIIONAL COURSES :

FLA 606 FLORI BUSINESS AND MANAGEMENT 2+0

Theory : Floriculture: Global and Domestic scenario, word export and import of flowers and ornamental plants, Recent trends, flower auctions: domestic and International trade of loose and cut flowers, Marketing channels and price spread in traditional and cut flowers.

E-commerce in floriculture, Online information system dealing with e-floriculture, Rosebazar.com, Websites dealing with e-floriculture. Flower auctions in Holland, USA, UK, India etc.

Floriculture and WTO, Documentation and indexing of flowers and ornamentals, Export standards for different flowers and ornamentals, Flower seed business. Dry flowers: Scenario in domestic and international market. Essential oil industry in India and abroad, Trend in landscape business,

Nursery trade in India, Patent rights in relation to floriculture, Quarantine procedures for floriculture products, Import regulations for flowers, flower seeds and other ornamentals, Export regulations for floriculture items, Role of national agencies viz. NABARD, NHB, APEDA and others.

FLA 607 ADVANCES IN ROSE, ANTHURIUM AND ORCHID UNDER PRODUCTION COVER (2+1)

Theory: Importance, climate and soil, planting and management, irrigation, nutrition, training, pruning, use of growth regulators, weed management, manipulation of flowering, harvesting, transport, storage and post harvest physiology under cover . Genetics and breeding to produce superior varieties, breeding for disease and pest resistance.

Practicals : Identification, classification and description of commercial species / types / varieties. Important methods of propagation, training and pruning. Manipulation of flowering. Use of growth regulators and herbicides. Experiments on post harvest physiology techniques.

Crops: Rose, Orchid and Anthurium.

Suggested Reference:

L.C.De., Value additions in flowers and orchids
Bruhl,P., A guide to the orchids of Sikkim
Maheshwari,J.K. et.al., Orchids of India.
S.C.Dey., Pot culture of Roses
Prasad.S., Singh D. and Kumar U., Commercial Floriculture
Gorak singh, K.V.Prasad., Rose- A production manual
B P Pal ., The rose in India

FLA 608 PLANTING MATERIAL AND SEED PRODUCTION IN FLOWER CROPS (1+1)

Theory : Scope and importance of planting material in flower crops; Global and Indian scenario in planting material and flower seed production. Propagation techniques and nursery management.

Propagation structures, sanitary and phyto-sanitary issues, plug plant production, nursery standards, Hi-tech nurseries, micropropagation of ornamental plants.

F1 hybrid seed production advantages, steps involved in hybrid seed production, methods in production of F1 hybrids in different flowers like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum etc., pollination behaviour and isolation, pollination management.

Use of incompatibility and male sterility, maintenance of variety and seed production in open- pollinated crops.

Practicals : Demonstration of propagation techniques; Nursery management techniques; Plug plant production; Steps involved in hybrid seed production; Hybrid seed production in different flower crops like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum etc

Suggested Reference:

Varnangamudi., Advances in seed science and technology (vol:7) flower seed production

Damian Camina et al., Ornamental plant propagation in tropics Amarnath V., Nursery and landscaping

FLA 609 ADVANCES IN POST HARVEST HANDLING AND VALUE ADDITION OF ORNAMENTAL CROPS (2+1)

Theory : Importance and scope. Post harvest physiological and biochemical changes in ornamental. Maturity indices; harvesting, grading, bunching of cut-flowers; Factors affecting cut-flower longevity; Pretreatments for extending the vase life of cut flowers, pre-cooling, use of preservative solutions, growth regulators and other chemicals. Preparation of cut-flowers for market and transportation. Export requirement. Dutch auctioning system.

Importance, opportunities and prospects of value addition in floriculture; national and global scenario. production and exports, supply chain management.

Dry flower making including pot pourries, their uses and trade; extraction technology, uses, sources and trade in essential oils; aromatherapy; pigment and natural dyes extraction technology, sources, uses and trade.

Pharmaceutical and neutraceutical compounds from flower crops; petal embedded hand made paper making and uses, preparation of products like gulkand, rose water, gulroghan, attar, pankhuri.

Floral craft including bouquets, garlands, flower arrangements etc. tinting (artificial colouring) of flower crops; Women empowerment through value added products making.

Practicals : Maturity indices and harvesting; Equipments – grading, sorting, cleaning and preparation for marketing. Studies on vase life of flowers.

Dry flower making including pot pourries; extraction technology, uses, sources and trade in essential oils; Pigment and natural dyes extraction technology; pharmaceutical and neutraceutical compounds from flower crops; preparation of products likegulkand, rose water, gulroghan, attar, pankhuri; Petal embedded handmade paper making, floral craft including

bouquets, garlands, flower arrangements etc.; tinting (artificial colouring) of flower crops. Visit to flower auction centre, flower market and essential oil extraction unit.

Suggested Reference:

Varma and Anil., Post harvest technologies for commercial floriculture

Punnuswami., Post harvest techniques and management of dry flowers.

Salunke, D.K., Bhatt and Desai., 1990. Post harvest Biotechnology of flowers and ornamental plants.

S.K. Bhattacharjee and L.C. De., 2005. Post harvest technology of flowers and ornamental plants

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Ph. D.- FRUIT SCIENCE

CORE COURSES

Course No.	Course No.	Credits
FSC601	Advances in Fruit Production	2+1
FSC 602	Advances in Breeding of Fruit Crops	2+1
FSC 603	Advances In Growth And Development Of Fruit Crops	2+1
FSC 604	Application of Biotechnological tools in Fruits Crops	2+1
FSC 605	Management Of Abiotic Stress In Fruit Crops	2+1
	TOTAL	15

OPTIONAL COURSES

Course No.	Course No.	Credits
FSC 606	Genomics And Bioinformatics in Fruit Crops	2+0
FSC 607	National And International Current Issues in Fruits Production	3+0
FSC 608	Organic Production of Fruit Corps	1+1
FSC 609	Biodiversity and Conservation in Fruit Crops	1+1
FSC 610	Advances in Canopy Management in Fruit Crops	1+1
FSC 611	Advances in Banana Culture	1+1
FSC 612	Advances In Mango And Citrus Culture	1+1
FSC 613	Advances In Viticulture	1+1
	TOTAL	17

CORE COURSES

FSC 601 ADVANCES IN FRUIT PRODUCTION (2+1)

Theory: National and International scenario in fruit production, Recent advances in propagation-root stock influence, planting systems, High density planting, crop modeling, 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. Special crop specific problems and recent approaches for their management. Production strategies for export.Crops covered: Mango, Banana, Papaya, Grapes, Citrus, Guava, Sapota, aonla, Pomegranate, Jackfruit, Apple, Strawberry etc.

Practical : Survey of existing fruit cropping systems and development of a model cropping system, Estimating nutrient deficiency, Detection and diagnosis of physiological disorders in fruits-estimation of water use efficiency, soil test-crop response correlations, practices in plant growth regulation, studying physiological and biochemical responses, quality analysis. Study of export standards for different fruit crops. Visit to modern orchards and export units.

Suggested Reference

Bal, J.S. 1977. Fruit Production, Kalyani Publishers, New Delhi

Bose, T.K., Mitra, S.K and D. Sanyal (Ed). 2001. Fruits-Tropical and Sub-Tropical, Naya Udyog, Calcutta.

Singh, Amar, 1980. Fruit Physiology and Production, Kalyani Publishers, New Delhi.

Chattopadhyay, T.K. (ed) (1998) A Textbook on Pomology vol. II & III, Kalyani Publishers, Calcutta.

Chadha, K.L. And Pareek, D.P., 1993, Advances in Horticulture, Vol. II & III, Malhotra Publishing House New Delhi

FSC 602 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: Mango, Banana, Papaya, Grapes, Citrus, Guava Sapota, Pineapple, Avocado, Apple, Peaches, 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 5.7 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 and Sub-tropical. 3rd Ed. Vols. I, II. Naya Udyog. Calcutta

Chadha KL & Pareek OP. (Ed.). 1996. Advances in Horticulture. Vol. I. Malhotra Publ. House. New Delhi

Chadha KL & Shikhamany SD. 1999. The Grape: Improvement,Production and Post-Harvest Management. Malhotra Publ. House. New Delhi

Gowen S. 1996. Banana and Plantains. Chapman & Hall. London, UK.,

Janick J & Moore JN. 1996. Fruit Breeding. Vols.I-III. John Wiley & Sons. Hoboken, USA

Nijjar GS. (Ed.). 1977. Fruit Breeding in India. Oxford & IBH. New Delhi

Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency. New Delhi

Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. Advances in Citriculture. Jagmander Book Agency. Pitampura, Delhi

Stover RH & Simmonds NW. 1991. Bananas. Longman. Publishing House, London UK,

FSC 603 ADVANCES IN GROWTH AND DEVELOPMENT OF FRUIT CROPS (2+1)

Objective: Appraisal on the advances in growth regulation of fruit crops.

Theory : Ecophysiological influences on growth and development of fruit crops flowering, fruit set- Crop load and assimilate partitioning and distribution. 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.Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards.

Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production. Flower drop and thinning, fruitset 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, fruitset and fruit development stages.

Suggested Readings

Buchanan B, Gruiessam W & Jones R. 2002. Biochemistry & Molecular Biology of Plants. John Wiley & Sons. Hoboken, USA

Chadha, K.L. and O.P. Pareek, (Eds). 1993. Advances in Horticulture. Vol. III. Fruit Crops. Malhotra Publishing House, New Delhi.

Epstein E. 1972. Mineral Nutrition of Plants: Principles and Perspectives. Wiley.New York, USA

Fosket DE. 1994. Plant Growth and Development: A Molecular Approach. Academic Press. New York, USA

Hunt, R., 1979. Plant Growth and Analysis. Edward Aarnold, London.

Leoplod AC & Kriedermann PE. 1985. Plant Growth and Development. 3rd Ed. McGraw-Hill, New York.

Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency. New Delhi

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

Salisbury FB & Ross CW. 1992. Plant Physiology. 4th Ed. Wadsworth Publ. Belmont California

FSC 604 APPLICATION OF BIOTECHNOLOGICAL TOOLS IN FRUITS CROPS (2+1)

Objective: To familiarize the students and provide hands-on training on various techniques of plant tissue culture and their applications in improvement of horticultural crops.

Theory : Basic principles of plant tissue-culture; morphogenetic potential of higher plants and regeneration pathways. Application of plant tissue culture techniques in crop improvement with emphasis on fruit crops, single cell and suspension culture, in vitro mutagenesis, somaclonal variation, embryo culture and rescue, anther culture and haploid production. Protoplast isolation, fusion and organogenesis, Agrobacterium-mediated genetic transformation and cryobiology. In vitro germplasm conservation, genetic diversity analysis using DNA markers.

Practicals : General acquaintance with a tissue culture laboratory; Methods of aseptic culture and sterilization procedure; Stock solutions and preparation of culture media; In vitro culture establishment and plant regeneration, Embryo culture and embryo rescue;

Anther isolation and culture; In vitro mutagenesis using EMS and gamma irradiation; In vitro screening for sodium tolerance; Agrobacterium- mediated genetic transformation of tobacco; DNA isolation and molecular markers analysis of plants; Techniques of low temperature germplasm storage, cryo-preservation and visit to NBPGR cryo- bank.

Suggested Readings

Balasubramanian, D., Bryce, C.F.A., Dharmalingam, K., Green, J. and Jayamaran, K. 1998. London

Bojwani, S.S. and Razdan, M.K. 1983. Plant Tissue Culture: Theory and Practices, Elsevier, Amsterdam.

Chadha, K.L., Ravindran, P.N. and Sahijaram, Leela 2000. Bio-technology in Horticulture and Plantation Crops. Malhotra Publishing House, New Delhi.

Concepts in Biotechnology. University Press, India. Hyderabad

Gupta, P.K. 1999. Elements of Biotechnology, Rastogi publications, Meerut, India.

Hammerscchlag Z.A. and Litz, R.E. 1997. Biotechnology of Fruit and Nut Crops, CABI, U.K.

Primrose, S.B. 1987. Modern Biotechnology. Blackwell Scientific Co., USA.

Razdan, M.K. 1993. An Introduction to Plant Tissue Culture. Oxford & IBH, Publishing Co. Pvt. Ltd., New Delhi.

Singh, B.D. 1999. Biotechnology, Kalyani Publishers, Ludhiana.

Street, H.E. 1973. Plant Tissue and Cell Culture. Blackwell Publications, London.

Vasil, I.K. 1967. Cell Culture and Somatic Cell Genetics. Academic Press, London.

FSC 605 MANAGEMENT OF ABIOTIC STRESS IN FRUIT CROPS (2+1)

Theory :

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.). Pollution-increased level of CO_2, 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. 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. 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. 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 Reference

Bhumm A, 1988 Plant Breeding for Stress Environment. CRC. USA

Christiansen MN & Lewis CF, 1982 Breeding plant for Less Favourable Environments. Wiley Inter. Science. New York

Gupta US, 1990 Physiological Aspects of Dry Farming. Madison

Kramer PJ, 1980 Drought Stress and the Origin of Adaptation. In: Adaptation of Plant to Water and High Temperature Stress. John Wiley & Sons. New York

Levitt J, 1972 Response of Plant to Environment Stresses. Academic Press. New York

Maloo SR. 2003. Abiotic Stress and Crop Productivity. Agrotech Publ. Academy. Udaipur India

Mussell H & Staples R. 1979. Stress Physiology in Crop Plants. Wiley Inter. Science. New York

Nickell LG. 1983. Plant Growth Regulating Chemicals. CRC. Boca Ration, Florida

Peter KV. (Ed.). 2008. Basics of Horticulture. New India Publ. Agency.New Delhi

Turener NC & Kramer PJ. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons. New York

OPTIONAL COURSES

FSC 606 GENOMICS AND BIOINFORMATICS IN FRUIT CROPS (2+0)

Theory : Introduction to bioinformatics and computational genomics, database fundamentals-biological databases, horticultural genome and protein databases, functional genomics. 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. 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. Phylogenetic algorithms-Treebase 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.

Suggested Reference

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. New York

Durbin R, Eddy SR, Krogh A & Mitchison G, 1999. Biological Sequence Analysis: Probabilistic Model of Proteins and Nucleic Acids. Cam UK

FSC 607 NATIONAL AND INTERNATIONAL CURRENT ISSUES IN FRUITS PRODUCTION (3+0)

Objective: To teach the students about the present situation of the different problems confronting fruit production and strategies to manage them.

Theory : National and international scenario in fruit production and trade. Climate change and fruit production. Abiotic and biotic factors influencing production, productivity and fruit quality.

Senile and seedling orchards- Replant problems and top working, in-situ rain water harvesting and enhancing water use efficiency, Nutrient and irrigation scheduling, Fruit crop based cropping systems, pesticidal residues and MRLs issues in fresh produce. GAPs in fruit production, HiTech banana & citrus production, Quality grape production in sub- tropical regions, crop regulation in pomegranate and guava, Quality plant material. Complex problems confronting fruit cultivation and their management: Alternate bearing in mango & apple, mango malformation, panama wilt of banana, citrus decline, guava wilt, coconut wilt, apple scab, chilling and pollination problems in temperate fruits, frost and virus problems in papaya and bacterial oil spot in pomegranate.

Suggested Readings

Blumm, A. 1988. Plant Breeding for Stress Environments. CRC Press, USA.

Bose, T.K., Mitra S.K., Farooqi A.A. and Sadhu, M.K. 1999. Tropical Horticulture. Vol. I. Naya Prokash, Kolkata.

Bose, T.K., Mitra, S.K. and Sanyal, D. (Ed.). 2002. Fruits of India – Tropical and Sub-tropical. 3rd Ed. Vols. I, II. Naya Udyog, Kolkata.

Chadha, K.L. and Pareek, O.P. (Eds.). 1996. Advances in Horticulture. Vol. II to IV. Malhotra Publ. House, New Delhi.

Chadha, K.L. and Rethinam, P. (Eds.). 1993. Advances in Horticulture. Vol. IX. Plantation Crops and Spices. Part-I. Malhotra Publ. House, New Delhi.

Christiansen, M.N. and Lewis, C.F. 1982. Breeding Plants for Less Favourable Environments. Wiley Inter. Science, USA.

Hsiao, T.C. 1973. Plant Responses to Water Stress. Ann. Rev. Plant Physiology 24: 519-570. University of California Davis

Levitt, J. 1972. Response of Plants to Environmental Stresses. Academic Press, USA.

Nakasone, H.Y. and Paull, R.E. 1998. Tropical Fruits. CABI, UK.

Turener, N.C. and Kramer, P.J. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons. New York

FSC 608 ORGANIC PRODUCTION OF FRUIT CORPS (1+1)

Objective: To develop understanding of organic horticulture production system including GAP.

Theory : Organic horticulture – definition, synonyms and misnomers, principles, methods, merits and demerits. Organic farming systems, components of organic horticultural systems, different organic inputs, their role in organic horticulture, role of biofertilizers, biodynamics and the recent developments. 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. GAP - Principles and management, HACCP exercise, certification of organic products and systems, agencies involved at national and international levels, standards evolved by different agencies. 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 organicproducts, 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. New Delhi

Lampkin N & Ipswich. 1990. Organic Farming. Farming Press. London.

Lampkin NH & Padel S. 1992. The Economics of Organic Farming – An International Perspective. CABI. UK

Palaniappan and Annadurai. 2008. Organic Farming- Theory and Practise. Scientific Publ. Jodhpur, India

Peter KV. 2008. (Ed.). Basics of Horticulture. New India Publ. Agency. New Delhi.

Rao S. 1977. Soil Microorganism and Plant Growth. Oxford & IBH. New Delhi

FSC 609 BIODIVERSITY AND CONSERVATION IN FRUIT CROPS (1+1)

Objective: Understanding the principles of biodiversity and strategies in germplasm conservation of fruit crops.

Theory : Biodiversity and conservation; issues and goals, centers of origin of cultivated fruits; primary and secondary centers of genetic diversity. Present status of gene centers; exploration and collection of germplasm; conservation of genetic resources – conservation in situ and ex situ. Germplasm conservation- problem of recalcitrancy - cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine. Intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group. GIS and documentation of local biodiversity, Geographical indication.

Crops: Mango, sapota, citrus, guava, banana, papaya, grapes, jackfruit, custard, apple, ber, aonla, malus, Prunus sp. and litchi.

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 centersof 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 andTomorrow. Cambridge University Press. Cambridge UK

Peter KV & Abraham Z. 2007. Biodiversity in Horticultural Crops. Vol. I. Daya Publ. House. New Delhi

Peter KV. 2008. Biodiversity of Horticultural Crops. Vol. II. Daya Publ. House.New Delhi

FSC 610 ADVANCES IN CANOPY MANAGEMENT IN FRUIT CROPS (1+1)

Objective:To impart knowledge about the principles and practices in canopy management of fruit crops.

Theory : Canopy management - importance and advantages; factors affecting canopy development. Canopy types and structures with special emphasis on geometry of planting, canopy anipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies. Spacing and utilization of land area - Canopy classification; Canopy management through rootstock and scion. Canopy management through plant growth inhibitors, training and pruning and management practices. 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. Delhi

Pradeepkumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. Management of Horticultural Crops. New India Publ. Agency. New Delhi

FSC 611 ADVANCES IN BANANA CULTURE (1+1)

Theory : Recent area, production, marketing and export. Recent advances in production technology and culture of Banana. Approaches for organic production of banana. Production problems and management approaches. Important case studies in banana. Problems and prospects of crop improvement in banana.

Practicals : Identification of varieties/clones. Propagation methods. Study of vegetative growth, flowering and fruiting. Study of special horticultural practices. Criteria for harvesting and ripening. Important pests, diseases and their management. Orchard efficiency analysis. Visit to progressive orchards and research centre.

Suggested Reference

Robinson, J.C., 1996, Bananas and Plantians, CAB UK

Kanchan, K, and Srivatsava, 2009, Systemic description of fruit crops, International Book Distributing co. Lucknow

Chadha, K.L. and O.P. Pareek, (Eds). 1993. Advances in Horticulture. Vol. III. Fruit Crops. Malhotra Publishing House, New Delhi.

FSC 612 ADVANCES IN MANGO AND CITRUS CULTURE (1+1)

Theory : Recent area, production, marketing and export. Recent advances in production technology and culture of Citrus. Approaches for organic production of citrus. Production problems and management approaches. Important case studies in citrus. Problems and prospects of crop improvement in citrus.

Practicals : Identification of varieties/clones. Propagation methods. Study of vegetative growth, flowering and fruiting. Criteria for harvesting and ripening. Important pests, diseases and their management. nutritional disorders and their management strategies, Orchard efficiency analysis. Visit to progressive orchards and research centre.

Suggested Reference

Shaym Singh, 2001, Citrus, International Book Distributing Co. Lucknow

Ting, S.V., Russell, L., 1986, Citrus Fruits and their Products, Marcel Dekker Inc. New York

Kanchan, K, and Srivatsava, 2009, Systemic description of fruit crops, International Book Distributing co.Lucknow

Chadha, K.L. and O.P. Pareek, (Ed). 1993. Advances in Horticulture. Vol. III. Fruit Crops. Malhotra Publishing House, New Delhi

FSC 613 ADVANCES IN VITICULTURE (1+1)

Theory : Recent area, production, marketing and export. Recent advances in production technology and culture of grape including wine grape. Approaches for organic production of grape. Production problems and management approaches. Important case studies in grape. Problems and prospects of crop improvement in grape.

Practicals : Identification of varieties/clones. Propagation methods. methods of training and pruning, bud analysis, Study of vegetative growth, flowering and fruiting. Criteria for harvesting and ripening. Important pests, diseases and their management. Phsiological disorders and their management. Vineyard efficiency analysis. Visit to progressive vineyard and research centre.

Suggested Reference

Shanmugavelu, 2003. Grape Cultivation and Processing, Agrobios (India) Jodhpur

Kanchan, K, Srivatsava, 2009, Systemic description of fruit crops, International Book Distributing co. Lucknow

Chadha, K.L. and O.P. Pareek, (Ed). 1993. Advances in Horticulture. Vol. III. Fruit Crops. Malhotra Publishing House, New Delhi

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Ph. D -POSTHARVEST TECHNOLOGY

CORE COURSES

Course No.	Course No.	Credits
PHT 601	Physiology of ripening and senescence	1+1
PHT 602	Novel processing technologies for horticultural produce	2+1
PHT 603	Storage techniques and supply/cold chain management of horticultural produce	2+1
PHT 604	Advances in packaging technology of horticultural produce Designing of horticulture processing plant	1+1
PHT 605	Advances in laboratory techniques in post harvest	1+1
PHT 606	technology	1+2
	TOTAL	15

OPTIONAL COURSES

Course No.	Course No.	Credits
PHT 607	Texture and rheological properties of food product	1+1
PHT 608	Nanotechnology and its application in post harvest technology	2+0
PHT 609	Food laws, regulations and quality management	2+0
PHT 610	Advances in processing of medicinal and aromatic crops	1+1
PHT 611	Advances in wine technology	1+1
PHT 612	Food enzymes and horticulture waste utilization	1+1
PHT 613	Functional foods and nutraceuticals	1+1
PHT 614	New product development in horticultural produce	1+1
PHT 615	Food chemistry	1+1
PHT 616	Food toxicology	1+1
PHT 617	Computer application in food industry	1+1
	TOTAL	15

PHT 601 PHYSIOLOGY OF RIPENING AND SENESCENCE (1+1)

Theory :

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

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

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

UNIT IV : Ethylene biosynthesis, perception and molecular mechanism of action; regulatory role of ethylene in senescence and ripening. Approaches to manipulate ethylene biosynthesis and action.

UNIT V : Alternate post harvest methodology and quality attributes. Scope for genetic modification of post harvest life of horticultural crops.

Practicals : Physiological and biochemical changes during ripening and senescence, estimation of ethylene during ripening and senescence, determination of reactive oxygen species and scavenging enzymes, measurement of dark and alternate respiration rates during ripening and senescence. Estimation of ripening related enzyme activity, cellulases, pectin methyl esterases, polygalacturonase, regulation of ripening etc.

Suggested Readings (Up date)

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

KHAN, N.A., 2006. Ethylene action in plants. Springer Verlag.

BARTZ, J. A. AND BRECHT, J. K., 2003. Post harvest physiology and pathology of vegetables. Marcel Dekker Inc.

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

PALIYATH, G., MURR, D.P., HANDA, A.K. AND LURIE, S. 2008. Post harvest biology and technology of fruits, Vegetables and Flowers. Blackwel Publishing, Iowa, UAS.

NOODEN, L.D., 2004. Plant cell Death Processes. Elsevier Science, E Sevier Academic Press

PAJARATHNAM, S AND RAMTEKE, R.S., 2001., Advances in preservation and processing technology of fruits and vegetables. By N, PA pub

SURESH KUMAR, P., SAGAR, V. R. AND MANISH, K., 2009. Post harvest physiology and quality management of fruits and vegetables. ATPA pub. ISBN

Kays, S.J., 1991, Post Harvest Physilogy and perishalde plant prodcts, CBS publishers and distributers.

PHT 602 NOVEL PROCESSING TECHNOLOGIES FOR HORTICULTURAL PRODUCE (2+1)

Theory : UNIT I : Recent advances in processing technologies: aseptic processing, individual quick freezing and cryogenic freezing, membrane technology, extrusion cooking, vacuum frying, ohmic heating, microwave processing and dielectric heating.

UNIT II : Non thermal processing -irradiation, pulsed electric field, magnetic fields, pulsed light treatment, high pressure processing, ultrasound, linear induction electron accelerator (LIEA), SCFE, ozonation, minimal processing and hurdle technology.

UNIT III : Functional foods and nutraceuticals, Enzymes and their application in food industry.

UNIT IV: Principles of food biotechnology, genetic modification of microorganisms in food industry (lactic acid bacteria, yeasts and moulds), production of high valued food products viz. enzymes, organic acids, SCP, nutritional additives, flavours, pigments.

Practicals : Methods of food fortification. Determination of thermal resistance of bacteria TDT and TDP. Determination of thermal death curve. Thermal process calculations. Study of problems associated with new technologies. Group discussions. Advances in fermentation technology. Recent trends in freeze preservation. Development of new products and value addition. Visit to processing industries.

Suggested Readings

BARBOSA-CANOVAS., 2002. Novel Food Processing Technologies. CRC. Press

BHUTANI RC., 2003. Fruits and vegetables preservation. Biotech Books, Delhi.

DA-WEN SUN., 2006. Thermal food processing: new technologies and quality issues. CRC/Taylor & Francis.

GOULD, G.W., 2000. New Methods of Food Preservation. CRC. springer science

PHILIP R., 2001. Thermal technologies in food processing. CRC Press.

RAMASWAMY, H. and MARCOTTE, M., 2006. Food Processing: Principles and Applications. Taylor & Francis.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub

PHT 603 STORAGE TECHNIQUES AND SUPPLY/COLD CHAIN MANAGEMENT FOR HORTICULTURAL PRODUCE (2+1)

Theory :

UNIT I :Controlled atmosphere, modified atmosphere, hypobaric storage, cold storage.

UNIT II : Building blocks of supply chain network, performance measures, decisions in supply world and models.

UNIT III : Supply chain inventory management. Use of stochastic models and combinatorial optimization in supply chain planning, layout, capacity planning, inventory optimization, dynamic routing and scheduling.

UNIT IV : Internet technologies and electronic commerce in supply chain management related to Enterprise resource planning, Q procurement, e-logistics, internet auctions, e-market and business process optimization.

UNIT V : Introduction, scope and importance of cold chain in food processing industry and retail chain, components of cold chain and integration. Products going in cold chain, their temperature and humidity requirements, packaging needs and their compatibility in cold chain. Stages and points of control in cold storages and structures, functions in cold storages, pallet layout and stacking options, flexibility storage systems cold chain transportation in land and export, retail & supermarket cold chain & display systems.

UNIT VI : Temperature recording devices used during transport, documentation and traceability, Risk management problem diagnosis, cost benefit studies for type of transport, loading & unloading, storage duration.

Practical : Problems and case studies related to storage techniques and SCM, Demonstration of various models in decision making, case studies for SCM in processing of fruits/vegetable, case study for export of one perishable and one non perishable food, visit to various retail outlets and export oriented units.

Suggested Readings:

CHATTOPADHYA, S. K., 2007. Handling, transportation and storage of fruits and vegetables. Gene-Tech books, New Delhi.

CHOPRA, S. AND MEINDEL, P., 2002. Supply Chain Management: Strategy, Planning and Operation. Prentice Hall.

LEVI, D. S., KAMINSKY, P. AND LEVI, E. S., 2000. Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies. Mc Graw Hill.

SHAPIRO, J. F., 2001. Modeling the Supply Chain. Duxbury Thomson Learning.

VISWANADHAM N., 2000. Analysis of Manufacturing Enterprises. Kluwer.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By N,PA pub

PHT 604 ADVANCES IN PACKAGING TECHNOLOGY OF HORTICULTURAL CROPS (1+1)

Theory:

UNIT I : Active packaging techniques, Intelligent packaging techniques, novel packaging techniques, Oxygen scavenging technology, Ethylene scavenging technology, Carbon dioxide and other scavengers, Antimicrobial food packaging: development of antimicrobial packaging system, Factors affecting the effectiveness of antimicrobial packaging.

UNIT II : Non-migratory bioactive polymers (NMBP) in food packaging, Advantages of NMBP, limitations, inherently bioactive synthetic polymers: types and applications, Polymers with immobilized bioactive compounds.

UNIT III : Time-temperature indicators (TTIs), Defining and classifying TTIs, Requirements for TTIs, The development of TTIs, Current TTI systems, Maximizing the effectiveness of TTIs, Using TTIs to monitor shelf-life during distribution, Using TTIs to optimize distribution and stock rotation.

UNIT IV : Packaging-flavour interactions, Factors affecting flavour absorption, role of the food matrix, role of differing packaging materials, Case study: packaging and lipid oxidation, Modeling flavour absorption, Packaging–flavour interactions and active packaging, Novel MAP applications for fresh-prepared produce, Novel MAP gases, Testing novel MAP applications, Applying high O_2 MAP. Recycling of packaging materials.

Practicals: Identification of plastic film material - specific gravity test, melting and odour test, burning test, solubility test. General quality control

tests carried out on papers, plastic films, foils and multilayered films - chloride test, pH test, moisture content, tensile test, bursting test, tearing resistance, puncture and other impact tests, insect penetration test, heat sealing strength, toxicity test, colour migration test. Testing of lacquered tin plate sheets; Measurement of tin coating weight by Clarke's method.

Determination of GTR and WVTR in different packaging materials, use of oxygen and ethylene scavengers in packaging of fresh fruits, application of anti microbial packaging for moisture sensitive foods, evaluation of pesticide residue migration from package to food, application of MAP and active packaging in selected foods, determination of oxidative changes in packaged foods, comparative evaluation of flexible and rigid packages for fragile foods, packaging of foods under inert atmosphere. Prediction of shelf life of foods, selection and design of packaging material for different foods.

Suggested References:

AHVENAINEN , R., 2001. Novel Food Packaging Techniques. CRC.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub

PHT 605 DESIGNING OF HORTICULTURE PROCESSING PLANT (1+1)

Theory:

UNIT I :Plant design concepts and general design considerations; plant location – location factors and their interaction with plant location, location theory models, computer aided selection of the location; feasibility analysis and preparation of feasibility report; plant size- factors affecting plant size and their interactions, estimation of break even and economic plant size;

UNIT II : Product and process design, process selection; process flow charts, computer aided development of flow charts, equipment selection including economic analysis of equipment alternatives; plant layout including computer aided development and evaluation, layout symbols; planning and design of services facilities, human resource, product packaging and marketing system;

UNIT III : Hygienic design aspects and workers safety; functional design of plant building and selection of building materials; estimation of capital investment, analysis of plant costs and profitability; management techniques in plant design including applications of network analysis; preparation of project report and its appraisal.

Practicals: Each student will be asked to select a food processing plant system and develop a plant design report which shall include product identification and selection. Site, estimation of plant size, process and equipment selection, process flow sheeting, plant layout and its evaluation. Visit to food parks.

Suggested References:

ANTONIO, L. G. AND GUSTAVO, V. BARBOSA-CANOVAS., 2005. Food Plant Design. Taylor and Francis.

GEORGE, D. S. AND ATHANASIOS, E. K., 2002. Hand book of food processing equipment. Kluwer Academic

ZACHARIAS, B. M. AND GEORGE, D. S., 2003. Food Process Design. Marcel Dekker.

ZACHARIAS B. M. AND GEORGE D. S., 2007. Food plant economics. 2007. CRC Press. London

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub

PHT 606 ADVANCED LABORATORY TECHNIQUES IN POST HARVEST TECHNOLOGY (1+2)

Theory:

UNIT I : Importance of quality of processed foods. Principles of food quality assurance. Introduction to quality evaluation. Food grades, standards, laws and regulations.

UNIT II : Sampling procedure for food analysis. Advances in techniques of food analysis for carbohydrates, organic acids, vitamins, polyphenols, flavonoids, minerals, anthocyanins, enzymes; Rheological techniques and instrumentation used in food industry.

UNIT III : Determination of browning and associated reactions in processed foods and their implications. Analysis of food additives like food colour, antioxidants, emulsifier, etc. Analysis of pesticide residues, metallic contaminants, aflatoxin. Analysis of food flavours. Quality analysis of processed fruits and vegetables, coffee, tea and spices. Identification and enumeration of microbial contaminants.

UNIT IV :Principles of chromatography (GC, GCMS, HPLC, LCMS), spectrophotometry (Atomic absorption spectrophotometer, ICAP spectrophotometer), ICP-MS, ICPOES, NMR, ESR, amino acid analyser, flame photometry, electrophoresis, colour measurement in foods, IRGA, Radio-isotopic techniques. Non destructive quality evaluation (NDQE)- E-nose,

E-tongue, machine vision. electrophoresis. Sample preparation for quality analysis. Energy calculation, sample calculations. Texture analysis. Rheology of different foods. Instrumental colour analysis. Sensory evaluation and microbiological examinations of fresh and processed products;

Estimation of tannin/phytic acid by spectrometric method; moisture and fat analysis by NIR spectroscopy; Separation and identification of sugars in fruit juices; Separation and identification of carotenoids by column chromatography; Estimation of respiration in fruits and vegetables, flavour profile in essential oils using GC; Identification and determination of organic acids by HPLC; capsaicin content and Scoville Heat Units in chillies; Heavy metal analysis using atomic absorption spectrometry; Residue analysis.

Suggested References:

AOAC International., 2003. Official methods of analysis of AOAC International. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities. AVI Publ.

LEENHEER, A. P., LAMBERT, W. E. AND BOCXLAER, J. F., 2000. Modern Chromatographic Analysis of Vitamins. 3rd Ed. Marcel Dekker.

.MASLOWITZ , H., 2000. Applied sensory analysis of food .Vol. I & II. CRC Press.

RANGANNA, S., 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw-Hill

TAYLOR, A., 2002. Food Flavour Technology. Sheffield Academic Press.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub

OPTIONAL COURSES

PHT 607 TEXTURE AND RHEOLOGICAL PROPERTIES OF FOOD PRODUCTS (1+1)

Theory:

UNIT I :Concept of Rheology- definition of ideal bodies, rheological models, viscoelastic characterization, creep relaxation dynamics;

UNIT II : Methods of introducing non-linearity in models; complex modulus; rheological characterization and modeling for various liquid foods, flow curves; dynamic behaviour of viscoelastic bodies, frequency response;

UNIT III : Viscometry- back extrusion viscometry and mixer viscometry; interaction between human organ responses and machine measurements in food product quality characterization; rheological responses and equipment design.

Practicals: Laboratory exercises on basic rheological parameters of food materials creep and stress relaxation tests on selected food materials, measurement of viscosity of liquid foods using various devices at various temperatures and solid concentrations, measurement on food texture using INSTRON machine, measurement of load deformation characteristics of food materials using INSTRON machine, analysis of available data on rheological properties.

Suggested References:

FAITH, A. M., 2001. Understanding Rheology. Oxford University Press.

FIGURA, L. O. AND TEIXEIRA, A. A., 2007. Food Physics. Springer Publ.

MALCOLM, C. B., 2002. Food texture and viscosity. Academic Press.

RAO, M. A., 2007. Rheology of fluids and semisolid fluids – principles and applications. Springer

JOSHI, V. K., 2006. Sensory science, principles and application in food evaluation. ATPA pub. ISBN 8183210538.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub

PHT 608 NANOTECHNOLOGY AND ITS APPLICATION (2+0)
IN POST HARVEST TECHNOLOGY

UNIT I : Nanotechnology- Definition, Concepts-Top down and Bottom up, History and introduction, growth of nanofood market, nanotechnology in India, special features of nanotechnology, applications of nanotechnology in food and agriculture, concept of nanofood.

UNIT II Applications of nanotechnology in packaging, anti microbial nature, O_2 scavenging, nano sensors and smart packaging, nano composite based package, nano based biodegradable package, nano food additives.

UNIT III : Nanoencapsulation and food fortification, probiotics, nanosensors for microbial detection, commercial products, safety laws and regulation.

Suggested references:

HUANG, Q., 2012, Nanotechnology in the Food, Beverage and Nutraceutical Industries, 1st Edn, Woodhead Publishing Series in food science, technology and nuntrition.

LYNN, J. F., WILLEM N,., ARNOUT, F. AND FRANS, K., 2011. Nanotechnology in the Agri-Food Sector.

DEBASIS, B., MANASHI B., HIROYOSHI, M. AND FEREIDOON, S., 2013. Bio-Nanotechnology: A Revolution in Food, Biomedical and Health Sciences.

SINGH, H. P., KUMAR, A. AND PARTHASARTHY, V. A., 2013. Nanotechnology in agriculture- Advances in Horticulture Biotechnology

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By N,PA pub

PHT 609 FOOD LAWS, REGULATIONS AND QUALITY MANAGEMENT (2+0)

Theory:

UNIT I :Horticulture food chain, Hazards – biological, chemical, physical; Quality assurance system and food safety; Challenges and opportunities for developing country for exports.

UNIT II : Reasons for implementing food safety and quality standards; Sampling procedures and plans; Food Safety and Standards Act, 2006; Strategies for compliance with international Agri-food standards: GAP, GMP, GHP, GLP, TQM, Sanitary and Phyto-sanitary (SPS) certification, statistical processed control, quality auditing.

UNIT III : Design and implementation of HACCP system; Steps in the risk management process; Traceability in food supply chains; microbial and biochemical analysis of food.

UNIT IV : Various organizations dealing with inspection, traceability and authentication, certification and quality assurance -FSSAI, APEDA. Indian and International quality systems and standards like Codex Alimentarius,EurepGAP, ISO, BIS, BRC, SQF. Consumer perception of safety; Ethics in food safety.

Suggested References:

Export/Import policy by Govt. of India.

LUNING, P. A., DEVLIEGHERE, F. AND VERHE, R., 2007. Safety in the agri-food chain. Wageningen Academic Publishers.

PETER, K. V., 2008. Basics in Horticulture. New India Publ. Agency.

RANGANNA, S., 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw-Hill.

MAHINDRU, S. N., 2004. Food Safety: Concepts and Reality. APH Publ. Corp.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub

PHT 610 ADVANCES IN PROCESSING OF MEDICINAL AND AROMATIC PLANTS (1+1)

Theory:

UNIT I : Post-harvest handling of plant material, preparation of plant material for packaging and extraction. Methods of extraction of crude alkaloids from medicinal crops viz. Sarpagandha, Steroid-bearing solanums, Ashwagandha, Henbane, Periwinkle, Costus, Coleus, Noni, Safed musli, Isabgol, Senna.

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, handling and preparation of different aromatic cropsfor essential oil extraction - jasmine, tuberose, oil-bearing rose, scented geranium, patchouli, davana, mints, basils, lemon grass, palmarosa, rosemary.

UNIT IV Principles and practices of different types of extraction - distillation, solvent extraction, enfleurage, soxhlet, supercritical fluid extraction, phytonics, counter current extraction.

UNIT V : Qualitative determination of essential oils. Quality analysis and characterization through chromatographs. Commercial uses of essential oils, aromatherapy. Commercial utilization of spent material. Storage of essential oils.

Practicals : 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 components 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 References:

BHATTACHARJEE, S. K., Ornamental Horticulture, Biotechnology and Post-harvest Technology. Vol. V. International Book Periodicals SupplyServices.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By N,PA pub

PHT 611 ADVANCES IN WINE TECHNOLOGY (1+1)

Theory:

UNIT I : Types and present status of alcoholic beverages; present status of wine grape and wine industryin India and world; production technology of wine grapes; maturity index; post harvest handling and storage of wine grapes; technology of wine making; classification of wines; production of sparkling wine; factors affecting the quality of wine production; stuck and malolactic fermentation, monitoring and controlling of fermentation parameters of wine.

UNIT II : Ageing of wine - oak wood barrels and oak wood chips. Application of colours and additives in grape wine production. Production of wine from horticulture crops other than grapes. Packaging technology, labeling & storage of wines.

UNIT III : Sensory evaluation of wine, methods of sensory evaluation, basic taste of wine; taste of bitterness, acidity, salt, sweetness, glycerol and alcohol on tongue with reference to sensory response and perception.

UNIT IV : International regulatory standards and guidelines for wine production and marketing; New concept of wine production - organic, biodynamic wine etc. Application of good hygienic and manufacturing practices in wine production. Wine analysis and quality control. Wine parks and nodal agencies for establishment of wine parks.

Practicals: Design, layout and operation of fermenters, types of fermenters.: Destemer, Crusher, Pneumatic/ hydraulic press, Screw pumps, Fermentation tanks with cooling jackets/ cooling system, Filters, Vaccumized bottling plants, Wine cold stabilization tanks, Water softening plant, oak wood vats and barrels for maturation of wine.

Determination of pH and TSS of grape juice and wine, analysis of wine with respect to titrable acidity, alcohol (ethanol) percentage, volatile acidity, free SO_2 in wine / juice / must, total SO_2 in wine; Protein stability test / Heat stability test of wine; Tartarate and bitartrate stability test / Cold stability test of wine. Determination of acetaldehyde content of wine by titrimetric method. Determination of phenol content of wine by titrimetric method. Sensory analysis of hydrogen sulphide and Mercaptans in wine. Methanol estimation by Gas chromatography. Estimation of reducing and

total sugar by copper reduction technique. Determination of total tannin content by visible spectrometry. Evaluation of different sensorial quality parameters of wine. Visit to wine grapes orchard, winery and wine Park.

Suggested References:

GLAUDIO, D. AND FORMICA, J. V., 2001. Wine Microbiology. Science and Technology.

RONALD, S. J., 2008. Wine Science, 3rd Edition . Academic Press.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub

PHT 612 FOOD ENZYMES AND HORTICULTURE WASTE UTILIZATION (1+1)

Theory

UNIT I : Enzymes – classification, properties, characterization, kinetics and immobilization; fermentative production of enzymes (amylases,proteases, cellulases, pectinases, xylanases, lipases) used in food industry and their downstream processing.

UNIT II : Enzymes as processing aids: fruit juices-cell wall degrading enzymes for liquefaction, clarification, peeling, debittering, decolourization of very dark colored juices such as anthocyanins; oxidases as replacers of chemical oxidants; synergistic effect of enzymes; Enzyme processing for flavours i.e. enzyme-aided extraction of plant materials for production of flavours, production of flavour enhancers such as nucleotides.

UNIT III : COD and BOD. Bioremediation. Waste characteristics – sampling methods, analysis and standards for waste discharge. Survey and nature of waste from processing industry and their present disposal methods. Methods for waste and waste water reduction. In plant modifications and innovative processes.

UNIT IV : Recovery of useful materials from waste, viz., colour, essence, pectin, oils, etc. Utilisation of waste and by-products – new products, animal feed and single cell protein. Technology of treatments of waste effluent from fruit and vegetable industries. Immobilised bioreactor in waste treatment. Anaerobic bioreactor and energy production. Economics of effluent management.

Practicals : Assay of enzymes for activity, specific activity, kinetics, stability (temperature, pH and storage); Extraction and clarification of juices using enzymes;

Suggested Readings

WHITEHURST, R. AND LAW, B., 2002. Enzymes in Food Technology. Blackwell Publ.

VERMA, L. R. AND JOSH, V. R., 2000. Post harvest technology of fruits and vegetables - handling, processing, fermentation and waste management. Vol-2. Indus Publishing company.

IOANNIS, S. A., 2007.Waste Management for the Food Industries.

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NEESER, J. R. AND GERMAN, B. J., 2004. Bioprocesses and Biotechnology for Nutraceuticals. Chapman & Hall.

ROBERT, E. C., 2006. Handbook of Nutraceuticals and Functional Foods. 2nd Ed. Wildman.

SHI, J.(ED)., 2006. Functional Food Ingredients and Nutraceuticals: Processing technologies.. CRC.

WEBB, G. P., 2006. Dietary Supplements and Functional Foods. Blackwell Publ.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub.

PHT 613 FUNCTIONAL FOODS AND NUTRACEUTICALS (1+1)

Theory

UNIT I : Introduction to nutraceuticals: definitions, synonymous terms, basis of claims for a compound as a nutraceutical, regulatory issues for nutraceuticals including CODEX, ICMR/NIN.

UNIT II : Concept of angiogenesis and the role of nutraceuticals/functional foods; Nutraceuticals for human diseases and disorders – compounds and their mechanisms of action, dosage levels, contradications if any.

UNIT III : Manufacturing aspects of selected nutraceuticals such as Pigments, polyphenols, isoflavonoids, prebiotics and probiotics, glucosamine, phytosterols; Food fortification, enrichment, formulation of functional foods containing nutraceuticals – stability and analytical issues, labelling issues.

UNIT IV : Pre clinical and clinical testing of nutraceuticals and health foods; interactions of prescription drugs and nutraceuticals; adverse effects and toxicity of nutraceuticals; nutrigenomics – an introduction and its relation to nutraceuticals.

Practical : Market survey of existing health foods; identification and estimation of selected nutraceuticals (Pigments, polyphenols, isoflavonoids, glucosamine, phytosterols); production and quality evaluation of foods containing nutraceuticals; food fortification, enrichment; development of labels and its claims for health foods; visit to relevant processing Units.

Suggested Readings

BRIGELIUS-FLOHÉ, J. AND JOOST, H. G., 2006. Nutritional Genomics: Impact on Health and Disease. Wiley VCH.

GIBSON, G. R. AND WILLIAM, C. M., 2000. Functional Foods - Concept to Product.

LOSSO, J. N., 2007. Angi-angiogenic Functional and Medicinal Foods. CRC Press.

MANSON, P., 2001. Dietary Supplements. 2nd Ed. Pharmaceutical Press.

NEESER, J. R. AND GERMAN, B. J., 2004. Bioprocesses and Biotechnology for Nutraceuticals. Chapman & Hall.

ROBERT, E. C., 2006. Handbook of Nutraceuticals and Functional Foods. 2nd Ed. Wildman.

SHI, J.(ED)., 2006. Functional Food Ingredients and Nutraceuticals: Processing technologies.. CRC.

WEBB, G. P., 2006. Dietary Supplements and Functional Foods. Blackwell Publ.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By N,PA pub.

PHT 614 NEW PRODUCT DEVELOPMENT IN HORTICULTURAL PRODUCE (1+1)

UNIT I : Concept of product development, product success and failure, factors for success, process of product development, managing for product's success. Innovation strategy - possibilities for innovation, building up strategy, product development programme. Social trends as a frame work in new product innovation.

UNIT II : Types of products – fast foods, fabricated foods, convenience foods etc, The product development process - product strategy, product design and process development, product commercialization, product launch and evaluation.

UNIT III : The knowledge base for product development technology – knowledge of functional aspects of horticultural produce for product development, knowledge management, knowledge for conversion of product concept to new product, technological knowledge (product qualities, raw material properties, processing, packaging requirement, distribution and marketing).

UNIT IV : Role of consumers in product development - consumer behaviour, food preferences, avoiding acceptance, integration of consumer needs in product development and sensory needs. Managing the product development process, Improving the product development process –

key message, evaluating product development, innovative matrices, striving for continuous improvement, Improving success potential of new products, market exploration and acquisition, Legal aspects of new product launch.

Practicals: Market survey for identification of new horticultural crop based products. Assessing new products for their novelty. Locating new product opportunities, Assessment of raw materials availability, Laboratory exercise for development of a new product, analyzing the product for organoleptic and storage quality. Objective quality of new products. Testing the product for consumer acceptability. Planning of requirements for manufacture of new products in industry, Positioning of product in market, Launching and market evaluation. Input output analysis, Cost analysis for new products.

Suggested References:

EARLE AND EARLE 2001. Creating New Foods. Chadwick House Group.

EARLE, R. AND ANDERSON A,. 2001. Food Product Development. Woodhead Publ.

FULLER,. 2004. New Food Product Development - from Concept to Market Place. CRC.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub

PHT 615 FOOD CHEMISTRY (1+1)

UNIT II : Enzymes, minerals, phenolics, flavonoids, colourants, flavours, chemical additives, food contamination and toxic substances. Interaction

of constituents in food systems; changes during storage and processing; browning reactions in foods.

UNIT III : Chemistry of fruits, vegetables, essential nutrients- sources, functions, deficiency diseases; requirements and recommended dietary allowances.

Practicals: Determination of peroxidase and catalase activity. Comparison of different methods for moisture determination in food samples. Test for presence of carbohydrates, and proteins. Identification of gums. Estimation of ash and minerals, Determination of fat and protein content, determination of NEB, determination of total carotenoids; determination of reducing and total sugars, determination of rancidity. Determination of crude and dietary fibre.

Suggested references:

BAMJI, M. S., RAO, N. A. AND REDDY, V., 2003. Textbook of Human Nutrition. Oxford & IBH.

BAYNES, J. W., MONNIER, V. M., AMES, J. M. AND SUZANNE, R., 2005. The Maillard Reaction: Chemistry at the Interface of Nutrition, Aging, and Disease Thorpe. Annals of the New York Academy of Science.

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PHT 616 FOOD TOXICOLOGY (1+1)

Theory

UNIT I : Definition, scope and general principles of food toxicology; manifestation of toxic effects; classification of food toxicants; factors affecting toxicity of compounds; methods used in safety evaluation-risk assessments.

UNIT II : Antinutritional factors, Toxicants and allergens in foods derived from plants, animals, marine, algae & mushroom; food microbial toxins and food pathogens; Food Poisoning, food borne infections and disease.

UNIT III : Derived Food toxicants- Processing & Packaging; Toxicants generated during food processing such as nitrosamines, acrylamide, benzene, dioxins and furans; persistent organic pollutants.

UNIT IV : Toxicology & food additives; Toxicological aspects of nutrient supplements; Chemicals from processing such as fumigants, chlorinated

solvents, autoxidation products, carcinogens in smoked foods and pyrolysis, agrochemicals; heavy metals; intentional and unintentional additives; food adulteration.

Practicals : Protocol for detection & quantification of toxins in food, Detection of pesticide residues, antibiotic residues, hormones and heavy metals; Analysis of microbial and plant toxins; Immunoassays. Detection of food adulterants.

Suggested Readings

SHABBIR, S., 2007. Food Borne Diseases. Humana Press.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub

PHT 617 COMPUTER APPLICATIONS IN FOOD INDUSTRY 1+1

Theory :

UNIT I : Importance of computerization in food industries. Operating environments and information systems for various types of food industries

UNIT II : Role of Computer in Optimization: Introduction to operational Research; A Computer Oriented Algorithmic approach; Queuing systems and waiting models; PERT, CPS and CPM.

UNIT III : Food Process Modeling and Simulation; CAD and CAM in Food Industry: instrumentation, process control, inventory control, Automation, Robotics, Expert system and artificial intelligence.

Practical : Applications of MS Excel to solve the problems of food technology: Statistical quality control, Sensory evaluation of food and Chemical kinetics in food processing; Use of word processing software for creating reports and presentation; Familiarization with the application of computer in food industries - Fruit & Vegetable processing Unit; Familiarization with software related to food industry; Ergonomics application in the same; Visit to Industry and case study problems on computer.

Suggested Readings

GILLETT, B. E. Introduction to Operation Research (A Computer Oriented Algorithmic Approach).

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub.

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Ph.D.-PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS (PSMA)

CORE COURSES

Course No.	Course No.	Credits
PMA 601	Advances In Production of Plantation Crops	2+1
PMA 602	Advances in Spice Production	2+1
PMA 603	Advances in Medicinal and Aromatic Crop Production Technology	2+1
PMA 604	Advances in Breeding of Plantation Crops and Spices	2+1
PMA 605	Advances in Breeding of Medicinal and Aromatic Crops	2+1
	TOTAL	15

OPTIONAL COURSES

Course No.	Course No.	Credits
PMA 606	Biotechnology in Plantation Crops and Spices	1+1
PMA 607	Post Harvest Processing and extraction in Medicinal and Aromatic Crops	2+1
PMA 608	Environmental Horticulture	2+1
PMA 609	Processing And Value Addition Of Plantation Crops	2+1
PMA 610	Processing and Value Addition of Spices	2+1
PMA 611	Genetic Resources Management of Medical, Aromatic, Dye and Pesticidal Plants (MADPS)	2+1
PMA 612	Production Technology of dye and Pesticidal plants	1+1
	TOTAL	19

CORE COURSES

PMA 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, 75 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: 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 References:

Alice Kurian and Peter, K.V., 2007, Commercial crops Technology" . New India Publishing Agency, Pitumpure, New Delhi -110 088, Pp 480

Anonymous, 1985. *Rubber and its Cultivation*. The Rubber Board of India. *Cashew*. CPCRI, Kasaragod.

Chadha, K. L. and Rethinam, P., 1994, Advances in Horticulture, - Plantation and Spice Crops, Part- I and II (Vol- 9) Malhotra Publishing House, New Delhi, India

Harler CR. 1963. The Culture and Marketing of Tea. Oxford Univ. Press.

ICAR, 2001, Hand Book of Horticulture, (Edited by K. L. Chadha), Directorate of Information and Publications of Agriculture, Indian Council of Agril. Research , Krishi Anusandhan Bhavan, Pusa, New Delhi – 110 012.

Kurian A & Peter KV. 2007. Commercial Crops Technology. New India Publ. Agency.

Kurian A and Peter KV. 2007 Commercial Crops Technology, New India Publ. Agency Management of Horticultural Crops. Part I, II. New India Publ.Agency.

Parthasarathy, V. A., Chattpadhyaya, P. K. and Bose, T. J(Editors)., 2005, " Plantation crops Vol.2, (Vol. 1 published in 2006 & 2) Published by Naya Udyog, 206, Bidhan Sarani Kolkatta – 700 006, pp. 520

Peter KV. 2002. Plantation Crops. National Book Trust.Pradeep Kumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008.

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.

Shanmugavelu, K. G., Kumar, N. and Peter, K.V., 2005, "Production technology of spices and plantation crops". Published by Agrobios (India), Behind Nassani Cinema, Chopasani Road, Jodhpur -342 003, PP. 550

Srivastava HC, Vatsaya B & Menon KKG. 1986. Plantation Crops – Opportunities and Constraints. Oxford & IBH.

Thampan PK. 1981. Hand Book of Coconut Palm. Oxford & IBH. 67

Willson KC. 1999. Coffee, Tea and Cocoa, Crop production Science in Horticulture, CABI Publishing

PMA 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 76 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. Precision 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

Practical : Description of botanical and varietal features-selection of 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 spice gardens, visit to spice plantations, commodity boards and spice based industries.

Suggested References:

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.

Eric Odoux, Michel Grisoni, 2010, Vanilla, Series: Medicinal and Aromatic Plants - Industrial Profiles, CRC Press , p126

Gupta S. (Ed.). Hand Book of Spices and Packaging with Formulae. Engineers India Research Institute, New Delhi.

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 68

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.

Purseglove, V.A., Utpala Parthasarathy and Kandiannan, K, 2008, “Spices, (Vol. 12), Today and Tomorrow Printers & Publishers, New Delhi

Ravindran PN 2000, Black Pepper: Piper nigrum, Series: Medicinal and Aromatic Plants - Industrial Profiles, CRC Press , p526

Ravindran PN and Madhusoodanan KJ. 2002. Cardamom: The Genus Elettaria, Series: Medicinal and Aromatic Plants - Industrial Profiles, CRC Press , p392.

Ravindran PN and Nirmal Babu, K and Shylaja, 2003, Cinnamon and Cassia: The Genus Cinnamomum, Series: Medicinal and Aromatic Plants - Industrial Profiles, CRC Press , p384.

Ravindran PN and Nirmal Babu, K. 2004. Ginger: The Genus Zingiber , Series: Medicinal and Aromatic Plants - Industrial Profiles, CRC Press , p576

Ravindran, PN, . Nirmal Babu, K and Kandaswamy Sivaraman, 2007, Turmeric: The genus Curcuma, Series: Medicinal and Aromatic Plants - Industrial Profiles, CRC Press , p504.

Shanmugavelu, K.G., Kumar, N. and Peter, KV. 2002, Production Technolgy of Spices and Plantation Crops, Agrobio (India). P 546

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.

PMA 603 ADVANCES IN MEDICINAL AND AROMATI CROP PRODUCTION TECHNOLOGY 2+1

Objective : To keep abreast with latest developments and trends in production technology of edicinal 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 phytochemical 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 lilly, 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., Long pepper and honey plant

UNIT V : Aromatic crops: Palmarosa, Lemongrass, citronella, vetiver, Geranium, Artemisia (A annua, A pallens, A absynthium) Mints, Ocimum, ambrette., Eucalyptus citriodora, Rosemary, patchouli, Dill and celery

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.

PMA 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 and oil palm

UNIT IV: Coconut and arecanut

UNIT V: Pepper and cardamom

UNIT VI: Nutmeg and cinnamon

UNIT VII: Turmeric, ginger, garcinia and garlic

UNIT VIII: Coriander, fenugreek, fennel and cumin

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 mutagens and colchicine for inducing mutation and ploidy changes, practices in different methods of breeding and in vitro breeding techniques.

Suggested References:

Anonymous 1985. Rubber and its Cultivation. The Rubber Board of India.

Bose, T. K., Mitra, S. K., Farooqui, A. A. and Sadhu, M. K.,(Eds), 1999, "Tropical Horticulture," Vol – I , Naya Prokash Publications, Calcutta, P. 784.

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.

Damodaran VK, Vilaschandran T &.Valsalakumari PK. 1979. Research on Cashew in India. KAU, Trichur.

Eric Odoux, Michel Grisoni, 2010, Vanilla, Series: Medicinal and Aromatic Plants - Industrial Profiles, CRC Press , p126

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.(Book), Ltd.

Nybe, E.V, Miniraj, N. and Peter, K.V., 2007, "Spices, (Horticulture Science Series-5 Edited by KV Peter.) New India Publishing Agency Pitam Pura, New Delhi-110 088.Pp. 316.

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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, Dioscorea, steroid bearing Solanum, Andrographis, Aloe vera, Phyllanthus and Henbane.

UNIT IV : Specific breeding objectives in medicinal and aromatic crops, Genetic bio diversity, Breeding problems and improvements in aromatic grasses, Geranium, Patchouli, Rosemary, dill and celery.

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.

OPTIONAL COURSES

PMA 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, Rubber, Cashew, pepper, cardamom, turmeric, Ginger.

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, 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.

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Singh BD. 2001. Biotechnology. Kalyani.

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PMA 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, aloe vera, periwinkle, senna and coleus.

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 and basils for essential oil extraction.

UNIT IV : Principles and practices of different types of extraction - distillation, solvent extraction, supercritical fluid extraction, Solvent free microwave

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 References:

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LEENHEER, A. P., LAMBERT, W. E. AND BOCXLAER, J. F., 2000. Modern Chromatographic Analysis of Vitamins. 3rd Ed. Marcel Dekker.

.MASLOWITZ , H., 2000. Applied sensory analysis of food .Vol. I & II. CRC Press.

RANGANNA, S., 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw-Hill

TAYLOR, A., 2002. Food Flavour Technology. Sheffield Academic Press.

RAJARATHNAM, S. AND RAMTEKE, R. S., 2011., Advances in preservation and processing technology of fruits and vegetables. By NIPA pub

PMA 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 CO_2 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 hortisystems. Subsistence farming systems of the world, threat and challenges.

UNIT IV : Environmental 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 horticultrral systems, assessment of biodiversity, pesticide residue analysis in horticultural produce.

PMA 609 PROCESSING AND VALUE ADDITION OF PLANTATION CROPS (2+1)

Theory : On – farm processing and the quality of finished products. Constraints in plantation sector. Prospects and scope for improvement. Consumer's preferences and requirements. Recent concepts in value addition and product diversification of plantation crops. (i) Coconut- Potential and scope of processing of fresh coconut. Processing for shelf stable products from coconut milk/ cream. Spray dried coconut milk powder defatted coconut powder, desiccated coconut, virgin coconut oil. Preservation of tender coconut water. Preservation of coconut inflorescence sap. Commercial production of toddy, jaggery, alcohol and vinegar. Latest methods in refining and de-odourizing of coconut oil. Solvent extraction of coconut oil. Coconut based foods-coconut chips, coconut biscuits, Nata-de-coco, coconut jam, coconut burfi, coconut honey. Coconut shell products, carvings, novelties and charcoal and activated charcoal. Coir manufacturing and coir industry in Karnataka, Geotextiles. (ii) Oil palm-Pilot processing, Quality characteristics of palm oil in comparison with coconut oil.(iii) Areca nut – Tender nuts : scope for manufacturing of diversified masticatory products. Utilization of by products like furfural and phenolics in industrial sector. Isolation and formulation of alkaloids for pharmaceutical uses. Diversified uses of areca spathe. (iv) Cashew nut – Small scale processing, hitech processing, grading, roasted nuts, flavoured nuts and other value-added products. Cashew apple: exploitation for production for unfermented beverages (juice, nectar, squash, syrup etc.) cashew apple pickle and fermented beverages (wine, alcohol, fenny). Scope of production of byproducts, viz, CNSL, testa tannins. (v) Cocoa – Improved methods of fermentation, drying and processing. Cocoa butter, cocoa powder and byproducts. Pilot manufacturer of chocolate. (vi) Coffee –Innovations in manufacturing of cherry coffee and powder. Characteristics of parchment coffee and its powder. Comparison of plain coffee vs. blended coffee (chicory blended). Advantages of specialty coffee. Decaffeinated coffee, Mysore Nuggets, Plantation A, Pea Berry, Extra Bold, Monsoonized Malabar, Washed Robusta coffee. (vii)Tea- Mechanical tea plucking. Orthodox and CTC tea. Specialty teas; Organic tea, Green tea, Oolong tea, white tea and other popular grades of tea. Chemistry of tea processing. (viii)Rubber: Methods in preservation and processing of latex. production of sheet rubbers and crepe rubbers. Studies on processing operations and machinery for Technically specified Rubber (TSR), Specialty Rubbers viz., Super processing rubbers, Constant Viscosity NR, Low Viscosity NR, Oil extended Natural Rubber (OENR), Graft Natural Rubber, Deproteinised Natural Rubber., Epoxidised Natural Rubber.

Practical : Processing of raw materials of plantation crops in the Lab for preparation of novel products. Visits to progressive farmers' plots for learning recent trends in on-farm processing. Quality characterization of plantation products. Visits to the local and export markets for familiarizing the currently traded products and their grades. Visits to processing units and R and D divisions.

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Alice Kurian and Peter, K.V., 2007, Commercial crops Technology" . New India Publishing Agency, Pitumpure, New Delhi -110 088, Pp 480

Chadha KL et al. (Eds.). 1993-95. Advances in Horticulture. Vol. IX. Plantation Crops and Spices. Malhotra Publishing House, New Delhi.

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Paine FA. 1987. Modern Processing, Packaging and Distributions Systems for Food. AVI Publ.

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.

PMA 610 PROCESSING AND VALUE ADDITION OF SPICES 2+1

Importance of on-farm processing, value addition and product diversification of spices. Adoption of improved on- farm processing methods. Cleaning and grading of harvested/ processed produce at farm level. Effects of pre-treatmentsviz., blanching, chemical treatments, better drying methods (solar, electric, LPG drying) , improved bleaching methods etc. on better physico-chemical qualities of productsLatest technologies in processing, value addition and product development of major spices viz., black pepper, cardamom (small and large), ginger, turmeric. Recent concepts in the processing of dried / de-hydrated spices, brining of fresh spices, frozen / freeze-dried spices, extraction of essential oils, oleoresins, super critical fluid extracts, essences, spice drops, encapsulated flavours, spice powders / curry powders, instant spices, spice pastes, extruded spices.

Modern methods in processing, value addition and product development of cinnamon, clove, nutmeg, Garcinia(kudampuli), allspice, tamarind. vanilla, coriander, cumin, fennel, fenugreek, celery, mustard, Quality up-gradation in spices and spice products. Production and certification for organic spices. Establishment of spices based processing units. Acquiring Logo, Certificates and License for internal trading and exports.

Practical : Harvesting indices of spices for dehydrated spices, canning, freezing, freeze-drying, essential oils, oleoresins, ground spices, brining of spices and other products. Visits to progressive farms for exposure to newer methods in on- farm processing. Acquainting on- farm operations like, cleaning, drying, blanching, bleaching, grading. Visits to wholesale markets and export zones for familiarizing the export grades. Distillation of essential oils, extraction of oleoresins, dehydrated spices, brining of spices, spice powders, other extracts and products.Preparation of white pepper, dry ginger, dry turmeric. Preparation of bleached products from spices. Physico chemical analysis on estimating the quality aspects of various spices. Visits to hi- tech processing units.

Suggested References:

Alice Kurian and Peter, K.V., 2007, Commercial crops Technology" . New India Publishing Agency, Pitumpure, New Delhi -110 088, Pp 480

Chadha KL et al. (Eds.). 1993-95. Advances in Horticulture. Vol. IX. Plantation Crops and Spices. Malhotra Publishing House, New Delhi.

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PMA 611 GENETIC RESOURCES MANAGEMENT OF MEDICINAL, AROMATIC, DYE AND PESTICIDAL PLANTS (MADPS) (2+1)

Geographic distribution of MADPs and principles of evolution. Regions of plant diversity, Nuclear centers and mega gene centers-analysis of variation in plant populations-gene pool sampling in field, tree and vegetatively propagated MADPs-Plant diversity in Indian gene centers -MADPs exploration and germplasm collection -planning and logistics-plant exploration and exchange-plant quarantine principles, regulations plant quarantine systems in India. Components of germplasm evaluation, descriptors. Some practical considerations of germplasm evaluation -conservation of MADPs genetic resources, Concept of base and active collections, long and short term storage of MADPs, gene bank management, recent approaches and role of biotechnology in PGR conservation- documentation and data base management, cataloguing gene bank information. MADPs genetic resources management in India and in International perspective- utilization and achievements in major MADPs. Concepts of rarity, threatened, endangered and extinction in MADPs.

Practicals : Collection and identification of different medicinal and aromatic plants present in nature and preparation of herbarium. Botanical, phyto-chemical and galanicals groupings of MADPs. Classification of MADPs based on plant parts used. Detection of adulterants and substitutes. Ethno botanical studies in tribal areas. Planning and layout of herbal gardens. Visit to herbaria,herbal gardens and important organisations engaged in collection and utilization of these plants.

PMA 612 Production Technology of dye and pesticidal plants (1+1)

Introduction, historical background, present status of production and utilization. Origin and distribution, species, varieties, economic parts. Ecology, crop management harvesting and extraction of dye and pesticides of plants viz., annatto, Mehandi, Indigo, Indian Maddar, Marigold, sappan, Pyrethrum, Red sanders, Neem, Sweet flag, Adhatoda, Clerodendron inerme, Vitex nigondu.

Practicals : Study of botanical characteristics of different species of dye and pesticidal plants. Study of propagation and nursery techniques. Study of pests and diseases and their management. Extraction and quantification of dyes and pesticide contents.

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Ph. D- VEGETABLE SCIENCE.

CORE COURSES

Course No.	Course No.	Credits
VSC 601	Advances in vegetable Production	2+1
VSC 602	Advances in Breeding of Vegetable Crops	2+1
VSC 603	Protected Cultivation of Vegetable Crops	2+1
VSC 604	Seed Certification, Processing and Storage of Vegetable Seeds	2+1
VSC 605	Abiotic Stress Management in Vegetable Crops	2+1
	TOTAL	15

OPTIONAL COURSES

Course No.	Course No.	Credits
VSC 606	Biotechnology of Vegetable Crops	2+1
VSC 607	Advances in Solanaceous Vegetables	1+1
VSC 608	Advances in Cucurbitecious Vegetables	1+1
VSC 609	Advances in Cole Crops	1+1
VSC 610	Advances in Bulbous And Root Vegetables	1+1
VSC 611	Export oriented vegetables	
VSC 612	Improvement and production technology of perennial and under exploited vegetables	2+1
VSC 613	Improvement and production technology of exotic vegetables	1+1
VSC 614	Vegetable breeding for biotic stress resistance	2+1
VSC 615	Vegetable breeding for quality traits	2+0
VSC 616	Biometircal genetics	1+1
	TOTAL	23

CORE COURSES

VSC 601 ADVANCES IN VEGETABLE PRODUCTION 2+1

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 and cauliflower

UNIT III :Bhendi, peas and beans, amaranthus and drumstick

UNIT IV : onion, Carrot 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 MG. (Eds.). 1986. Vegetable Crops in India . NayaProkash.

Bose TK, Som G &Kabir J. (Eds.). 2002. Vegetable Crops. NayaProkash.

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James L. Brewster, 2008, Onions and Other Vegetable Alliums 2 nd edition. CABI : 413.

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Kaloo G & Singh K. 2001. Emerging Scenario in Vegetable Research and Development. Research Periodicals and Book Publ. House.

Peter KV & Pradeepkumar T. 2008. Genetics and Breeding of Vegetables. Revised, ICAR.

Ram HH. 1998. Vegetable Breeding: Principles and Practices . Kalyani.

Rai N & Rai M. 2006. Heterosis Breeding in Vegetable Crops . New India Publ. Agency.

Kurup GT, Palanisami MS, Potty VP, Padmaja G, Kabeerathuma S & Pallai SV. 1996. Tropical Tuber Crops, Problems, Prospects and Future Strategies Oxford & IBH.

Singh NP, Bhardwaj AK, Kumar A & Singh KM. 2004. Modern Technology on Vegetable Production . International Book Distr. Co.

VSC 602 ADVANCES IN BREEDING OF VEGETABLE CROPS 2+1

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,

UNIT III : cabbage, cauliflower Bhendi,

UNIT IV : onion and Carrot,

UNIT V : peas, beans, Sweet potato and tapioca,

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.

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Chadha KL, Ravindran PN &Sahijram L. 2000. Biotechnology inHorticultural 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.

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Ram HH. 2001. Vegetable Breeding. Kalyani.

VSC 603 PROTECTED CULTIVATION OF VEGETABLE CROPS 2+1

Theory

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, CO_2 and humidity on growth of different vegetables, manipulation of CO_2, 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 stuctures.

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, CO_2, 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.

References :

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 &Som V. 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 SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE SEEDS 2+1

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. Seed treatment methods, seed priming and pelleting and synthetic seed technology;

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.

References

Agarwal P.K and Dadlani M. 1992. Techniques in seed science and technology. South Asian Publ.

Singh N.P., Singh D K, Singh Y K and Kumar V. 2006. Vegetable Seed Production Technology. International Book Distrng.Co

Singh SP.2001. Seed Production of Commercial Vegetables. Agrotech Publ. Academy.

Tunwar NS and Singh SV. 1988. Indian Minimum Seed Certification Standards. The Central Seed Certification Board, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi, pp: 388.

S. Rajan and B.L.Markose 2007. Propagation of Horticultural Crops. New Ibdia publishing agency.

VSC 605 ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS 2+1

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.

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Lerner HR (Ed).1999. Plant Responses to Environmental Stresses. Marcel Decker, Inc.

Maloo SR. 2003. Abiotic stresss and Crop Productivity. Agrotech Publ. Academy.

OPTIONAL COURSES

VSC 606 BIOTECHNOLOGY IN VEGETABLE CROPS 2+1

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, Y.P.S. 1991. (ed.) "Biotechnology in agriculture and forestry 17. High-tech and micropropagation 1." Springer-Verlag, Berlin Heidelberg New York.

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Glover MD. 1984. Gene Cloning : The Mechanics of DNA Manipulation. Chapman and Hall.

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Singh BD. 2010. Biotechnology. Kalyani.

SkoogY and Miller CO.1957. Chemical Regulation of Growth and Formation in Plant Tissue Cultured in vitro. Attidel. 11 Symp.on Biotechnology Action of Growth Substance.

Vasil TK, Vasi M, While DNR and 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 607 ADVANCES IN SOLANACEOUS VEGETABLES 1+1

Theory : Present status and prospects of solanaceous vegetables 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, 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 breedings; breeding techiques 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, export and processing, of:

UNIT I: Potato

UNIT II: Tomato

UNIT III: Brinjal

UNIT IV: Chilli and capsicum

Practical : Nursery techniques; 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; 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; 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.

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Paroda RS and Kalloo G. (Eds.). 1995. Vegetable Research with Special Reference to Hybrid Technology in Asia-Pacific Region. FAO.

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Ram HH. 1998. Vegetable Breeding: Principles and Practices. Kalyani Publishers, New Delhi, India.

Singh PK, Dasgupta SK and Tripathi SK. 2004. Hybrid Vegetable Development. International Book Distributing Co. Lucknow.

VSC 608 ADVANCES IN CUCURBITACIOUS VEGETABLES 1+1

Theory : Present status and prospects of cucurbitacious vegetable cultivation; nutritional and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; 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; low cost polyhouse; net house production; crop modeling, organic

gardening; vegetable production for pigments, evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and 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, export and processing, of:

UNIT I : Cucumber

UNIT II : Water melon

UNIT III : Musk melon

UNIT IV : Gourds

UNIT V : Squashes and pumpkins

Practical : Practices in cucurbitacious vegetable growing and organic gardening;; 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; 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 malls and packing houses. 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.

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Singh PK, Dasgupta SK and Tripathi SK. 2004. Hybrid Vegetable Development. International Book Distributing Co. Lucknow.

VSC 609 ADVANCES IN COLE CROPS 1+1

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, 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, export and processing, of

UNIT I : Cabbage

UNIT II :Cauliflower

UNIT III :Knol khol

UNIT IV : Sprouting broccoli and other cole crops

Practical : Nursery techniques; practices in vegetable growing and organic gardening; portrays; 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; 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 malls and packing houses. Designing of breeding experiments, Self incompatibility assay, 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, distant hybridization and embryo rescue techniques.

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Singh PK, Dasgupta SK and Tripathi SK. 2004. Hybrid Vegetable Development. International Book Distributing Co. Lucknow.

VSC 610 ADVANCES IN BULBOUS AND ROOT VEGETABLES 1+1

Theory : Present status and prospects of bulbous and root vegetable crops 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, 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, export and processing, of:

UNIT I : Onion

UNIT II : Garlic and other bulbous vegetable crops

UNIT III : Carrot

UNIT IV : Radish, turnip and beet root

Practicals : Nursery techniques; practices in bulbous and root vegetable crops growing and organic gardening; 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; 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 malls and packing houses. Designing of breeding experiments, identification of male sterile plants and assay, 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.

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Singh NP, Bharadwaj AK, Kumar A and Singh KM. 2004. Modern Technology on Vegetable Production. International Book Distributing Co. Lucknow.

VSC 611 EXPORT ORIENTED VEGETABLES 1+1

Objective :To acquaint students with export oriented requirements of vegetable crops

Theory :

UNIT I: India's position and potentiality in world trade; export promotion zones in India

UNIT II : Scope, produce specifications, quality and safety standards for export of vegetables viz., onion, chilli, okra, bittergourd, gherkin, etc

UNIT-III : Processed and value added products, post harvest managementfor export including packaging and cool chain; HACCP, codex ailmentarious, ISO certification; WTO 5.54 and it's implications, sanitary and photo sanitary measures

UNIT-IV : Seed and planting materials, Hi-tech nurseries, implications of PVP.

Practicals: Export promotion zones for vegetables and export of fresh vegetables and their products; quality standards of vegetables for export purpose; practical on quality standards for export, Quality standards of planting materials and seeds; Hi-tech nursery in vegetable crops, Sanitory and photo sanitary measures during export of vegetables;Post harvest management chain of vegetable produce for export

VSC 612 IMPROVEMENT AND PRODUCTION TECHNOLOGY (2+1)
OF PERENNIAL AND UNDER EXPLOITED VEGETABLES

Theory : Present status and prospects of perennial and under exploited vegetable crops cultivation; nutritional and medicinal values; climate and soil, 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; nutritional deficiencies, disorders and correction methods; different cropping systems; mulching; evolution, distribution, cytogenetics, genetic resources, genetic divergence,

types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inheritance pattern of traits, selection indices, breeding techniques for improving quantity, 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, export and processing, of

UNIT I: Drumstick, Curry leaf, Cassava, yams, Asparagus 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 food yam, lima bean, winged bean, vegetable pigeon pea, jack bean and sword bean.

UNIT V: Sweet gourd, spine gourd, pointed gourd, Oriental pickling melon, snake gourd, Chow chow, and little gourd (kundru).

Practicals: Nursery techniques and practices in perennial and under exploited vegetables crops growing and organic gardening; 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; 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; genetic variability, cytogenetic and genetic studies, Screening techniques for abiotic stresses, screening and rating for pest, disease and nematode resistance, estimation of quality and processing characters, screening for-quality improvement, induction and identification of mutants and polyploids, distant hybridization and embryo rescue techniques.

Suggested Reference:

Bhat K L 2001. Minor vegetables –untapped potential, Kalyani.

Indira P and Peter K V . 1984.Unexploited tropical vegetables. Kerala Agricultural University, Kerala.

Peter K v.(Ed) 2007-2008. Underutilised and underexploited Horticultural Crops. Vol. I-IV. New India Publishing Agency.

Rubatzky V E and Yamaguchi M (Eds).1997. World Vegetables: Principles, Production and Nutritive Values.Chapman and Hall.

Srivastava U , Mahajan R k, Gangopadyay K K, Singh M and Dhillon B S.2001 Minimal Descriptors of Agri –Horticultural Crops. Part II:

Vegetable Crops , New Delhi.

VSC613 IMPROVEMENT AND PRODUCTION TECHNOLOGY OF EXOTIC VEGETABLES (1+1)

Theory : Present status and prospects of exotic vegetable crops 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; 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, evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, breeding, inheritance pattern of traits, 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, export and processing, of: Parsley, Parsnip, rhubarb, lettuce, Zucchini, leek, Celeary, artichoke, asparagus, Chinese cabbage, Bab corn, red cabbage, broccoli, cherry tomato.

Practicals: Nursery techniques; practices in exotic vegetables crops growing and organic gardening; diagnosis of nutritional and physiological disorders; analysis of physiological factors I revisionike 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; 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 malls and packing houses. Designing of breeding experiments, identification of male sterile plants and assay, 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 Reference:

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Srivastava U , Mahajan R k, Gangopadyay K K, Singh M and Dhillon B S.2001 Minimal Descriptors of Agri –Horticultural Crops. Part II: Vegetable Crops, New Delhi.

VSC-614 VEGETABLE BREEDING FOR BIOTIC STRESS RESISTANCE 2+1

Theory

Unit I: Importance of vegetable breeding for biotic stress resistance; Classification of biotic stresses – major pests and diseases of economically important vegetabale crops - Concepts in insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defense responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants.

Genetic resources, genetics and breeding methods and the latest developments and achievements in breeding for resistance to pest and diseases in commercially important vegetables:

Unit II: Potato, tomato, brinjal, chilli and capsicum.

Unit III : cucumber, water melon, musk melon, peas and French bean

Unit IV: Cabbage, cauliflower, onion and okra

Practical : Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies. Phenotypic screening methods for major pests and diseases; Recording of observations; analyzing the data with respect to commercially important vegetable crops: Potato, tomato, brinjal, chilli, capsicum, cucumber, water melon, musk melon, peas, French bean, cabbage, cauliflower, onion and okra.

Suggested Reference:

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Dhillon, B. S., Saxena, S. Agrawal, A. and Tyagi, R. K. 2005, Plant Genetic Resources: Horticulture crops . Narosa publishing House. New Delhi , India

Gupta VK and Paul YS. 2001. Disease of vegetable crops, Kalyani Publishers, New Dehli, India.

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DOI: 10.1126/science.166.3905.593

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VSC 615 VEGETABLE BREEDING FOR QUALITY TRAITS 2+0

Theory : Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Nutritional improvement - A human perspective – Breeding vegetables for quality traits and value addition for fresh market- fruit colour, Texture and firmness, shelf life, flavour, Nutritional value-vitamins, minerals, proteins, carbohydrates, anti-nutritional factors, etc

Unit I: Solanaceous and legume vegetables

Unit II : Cucurbits and cole crops

Unit III: root and bulb crops, tuber and leafy vegetables

Breeding vegetables for quality traits for processing-Uniform ripening, Colour, Fruit pH, Titrable acidity, Soluble solids, reducing sugars, Viscosity, poly phenols, etc requirements for canning and different processed products like jam, jelly, ketchup, sauce, other concentrates, dehydrates, chips, French fry, etc

Unit IV: Potato, tomato

Unit V : Carrot, cabbage, pumpkin, squashes & leafy vegetables

Suggested Reference:

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Dhillon BS, Tyagi RK, Saxena S & Randhawa GJ. 2005. Plant Genetic Resources: Horticultural Crops. Narosa Publ. House.

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VSC 616 BIOMETIRCAL GENETICS 1+1

Theory

Unit I: Measures of central tendency and dispersion, mean, mode median, Standard deviation, coefficient of variance, product moment correlation coefficient and regression coefficient.

Unit II: 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 III: Principles of Analylis of Variance (ANOVA) - Expected variance components, random and fixed models; 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;

Unit IV: Discriminate function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance. Generation mean analysis;

Unit V: Mating designs- Diallel, partial diallel, line x tester analysis, NCDs; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for GxE analysis and stability parameters.

Practical : Working out biometrical parameters: Standard deviation, coefficient of variance, product moment correlation coefficient, regression coefficient, Genotypic variance, phenotypic variance, GCV, PCV, Heritability, Genetic advance / gain, Path analysis, Chi-square Test for heterogeneity, fitness of test for expected genetic ratios and detection of linkage.

Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression - Generation mean analysis: Scaling test, Joint scaling test, Stability analysis.D^2 analysis - Grouping of clusters and interpretation - Cluster 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. Use of computer software to work out above mentioned biometrical parameters.

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Arunachalam, V., 1974, The fallacy behind the use of modified line x tester design. Indian J. Genet. Plant Breed., 34: 280-287.

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Eberhart, S.A. and Russell, W.A., 1966, Stability parameters for comparing varieties. Crop Sci., 6: 36-40.

Falconer D. S. and Mackay T. F. C., Introduction to Quantitative Genetics, 1998, Longman Publ.

Gardner, C. O., 1963, Estimation of genetic parameters in cross pollinated plants and their implications in plant breeding. Statistical Genetics Plant Breeding. NAS-NRS Washington. D. C. Publication., 982: 228-240

Griffing, B., 1956, Concept of general combining ability in relation to diallel crossing system. Aust. J. Bio. Sci., 9: 463-493.

Hayman, B.L., 1958, The separation of epistatic from additive and dominance variation in generation means. Heredity, 12: 371-390.

Hayman, B.L. and Mather, K., 1955, The description on genetic interaction in continuous variation. Biometrics, 11: 69-82.

Kempthorne, O., 1957, An introduction to genetic statistics. John Wiley and Sons, New York, pp. 408-711.

Mather, C., 1949, Biometrical Genetics. Metheun and Co., London.

Panse, V.G., 1957, Genetics of quantitative characters in relation to plant breeding. Indian J. Gen., 17(2): 318-328.

Ram HH. 2001. Vegetable Breeding. Kalyani.

Singh R. K. and Chaudhary B. D., 1996, Biometrical Methods in Quantitative Genetic Analysis, Kalyani Publishers, New Delhi.

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Ph.D.-Plant Pathology

CORE COURSES

Course No.	Course No.	Credits
HPP 601	Advances in Mycology	2+1
HPP 602	Advances in Plant Virology	2+1
HPP 603	Advances in Plant Bacteriology	2+1
HPP 604	Advances in Plant Nematology	2+1
HPP 605	Molecular Basis of Host-Pathogen Interaction	2+1
	TOTAL	15

OPTIONAL COURSES

Course No.	Course No.	Credits
HPP 611	Principles and Procedures of Certification	1+0
HPP 612	Plant Biosecurity and Biosafety	2+0
HPP 613	Advances in Seed Pathology	1+1
HPP 614	Advances In Epidemiology Forecasting and Loss Assessment of Plant Diseases	1+1
HPP 615	Advances in Biological Management of Plant Diseases	1+1
HPP-616	Advances In Disease Resistance in Plants	1+1
	TOTAL	11

CORE COURSES

HPP 601 ADVANCES IN MYCOLOGY 2+1

Objective : To acquaint with the advances in Mycology.

Theory : UNIT I : General introduction, historical developments and latest 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.

Practicals : Identification of fungi up to species level. Study of conidiogenesis-phialides, porospores, arthospores. Study of fruit bodies in Ascomycotina. 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.

HPP 602 ADVANCES IN PLANT VIROLOGY 2+1

Objective : To educate about the advanced techniques and new developments in the field of Plant Virology.

Theory :

UNIT I : Mechanism of virus and virus like organisms, 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 viruses, satellite viruses and satellite RNAs.

UNIT IV : Gene expression and regulation, viral promoters, molecular mechanism of host-virus interactions and symptom expressions of 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) DIBA (iv) Western blots (v) (ab) 2-ELISA, vector transmission (one each with aphid, leaf hopper, thrips 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. Vius 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.

HPP 603 ADVANCES IN PLANT BACTERIOLOGY 2+1

Objective: To provide knowledge about the latest advances in phytobacteriology.

Theory :

UNIT I : Recent approaches for the identification and characterization of phytopathogenic bacteria. Ultrastructures and biology of bacteria.

UNIT II : Current trends in taxonomy of phytopathogenic procarya.

UNIT III : Role of enzyme, toxin, expolysaccharide, polypeptide signals in disease development. Mechanism of wilt (Ralstonia solanacearum) development, soft rot (Erwinia spp.) development, mechanism of Crown gall formation (Agrobacterium tumifaciens).

UNIT IV : Host-bacteria interactions, 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 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.

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 Univ. Press, Cambridge.

Starr MP. 1992. The Prokaryotes. Vols. I – IV. Springer Verlag, New York.

HPP 604 ADVANCES IN PLANT NEMATOLOGY 2+1

Objective:To keep abreast of the recent advances and to identify the trends in different fields of Nematology.

Theory :

UNIT I : Nematode ultra structure; current theories on non conventional approaches in nematode identification; evolution of parasitism

UNIT II : Genetic basis of plant resistance to nematodes and identification of resistance genes against major plant nematodes; applications of biotechnological methods in the development of resistant cultivars; incorporation of resistance by conventional and transgenic approaches; influence of microorganisms on plant nematode interaction.

UNIT III : Isolation, identification, host-specificity, mode of action culturing and field application of promising bio-control agents; their mass culturing, formulation, quality control, biosafety and registration, INM modules, management options in organic and precision farming, application of GIS and GPS technologies for surveillance and management.

UNIT IV : Host recognition plant nematode interaction: survival strategies in nematodes. Novel approaches for nematode management including genetic engineering.

Practical : Identification of species/ races of root- knot, cyst and other nematodes using PAGE, Histopathology using microtomy, screening techniques for assessment of resistance, Greenhouse experimentation the efficacy of fungal and bacterial biocontrol agents including PGPR, Isolation of nematode proteins and DNA, PCR- amplification of DNA for nematode identification.

Suggested Readings

Perry RN & Moens M. 2006. Plant Nematology. CABI, London.

Garrity GM, Krieg NR & Brenner DJ. 2006. Bergey's Manual of Systematic Bacteriology: The Proteobacteria. Vol. II. Springer Verlag, New York.

Southey JF. 1986. Laboratory Methods for Work with Plant and Soil Nematodes. HMSO, London.

Luc M, Sikora RA and Bridge J. 2005. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. CABI, Wallingford.

Khan MW. 1993. Nemic Interactions. Chapman and Hall, New York.

Chen Z X, Chen SY and Dickson DW. 2004. Nematology: Advances and Perspectives. Vol.II: Nematode Management and Utilization. CABI, Wallingford.

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.Fenoll C, Grundler FMW & Ohl SA. 1997. Cellular and Molecular aspects of Plant-Nematode Relationships. Kluwer Academic Press, Dordrecht.

Chen ZX, Chen SY and Dickson DW. 2004. Nematology: Advances and Perspectives Vol. II. Nematode Management and Utilization. CABI, Wallingford.

Poinar GO Jr and Jansson H-B. 1988. Diseases of nematodes. Vols. I, II. CRC Press, Boca Raton, Florida.

www.fao.org/docrep/010/a1140e/a1140e00.htm

http.//www.who.int/csr/resources/publications/biosafety/WHO_CDS_EPR_2006.pdf

HPP 605 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, phytoplasmas and viruses; recognition system, signal transduction.

UNIT III: Induction of defense respones- pathogenesis related proteins, HR, reactive oxygen species, phytoalexins and systemic acquired resistance (SAR & ISR), Programmed Cell Death, Viral induced gene silencing.

UNIT IV :Molecular basis of gene-for-gene approach; R-gene expression and transcription profiling, mapping and cloning of resistance genes and marker-aided selection, pyramiding of R genes.

UNIT V : Biotechnology and disease management; development of disease resistance plants using genetic engineering approaches, different methods of gene transfer, production of transgenic plants and bio safety issues related to GM crops.

Practical : Protein, nucleic acids isolation, plasmids extraction, PCR analysis, DNA and protein electrophoresis, transformation and trangenics.

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 PlantPathology - A Practical Approach. Vols. I & II, Oxford Univ. 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.

Stacey G & Keen TN. (Eds.). 1996. Plant Microbe Interactions. Vols. I-III.

Chapman & Hall, New York; Vol.IV. APS Press, St. Paul, Minnesota.

OPTIONAL COURSES

HPP 611 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.

UNIT III : Induction of defense responses- pathogenesis related proteins, HR, reactive oxygen species, phytoalexins and systemic acquired resistance (SAR & ISR), Programmed Cell Death, Viral induced gene silencing.

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 21st Century. CABI, UK.

ISHI-veg Manual of Seed Health Testing Methods.
http://www.worldseed.org/enus/

international_seed/ishi_vegetable.html ISHI-F Manual of Seed Health Testing Methods.

http://www.worldseed.org/en-us/international_seed/ishi_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 of India, New Delhi.

US National Seed Health System. http://www.seedhealth.org/

HPP 612 PLANT BIOSECURITY AND BIO SAFETY 2+0

Objective : To facilitate deeper understanding on plant biosecurity and biosafety issues in agriculture/ horticulture crops.

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 as per International Plant Protection Convention (IPPC), 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.pdfBiosecurity Australia.

www.daff.gov.au/ba;www.affa.gov.au/biosecurityaustraliaBiosecurity New Zealand. www.biosecurity.govt.nz

Chapman & Hall, New York; Vol. IV. APS Press, St. Paul, Minnesota.

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

HPP 613 ADVANCES IN SEED PATHOLOGY (1+1)

Theory

UNIT I : Economic importance of seed pathology in seed industry, plant quarantine, SPS under WTO and Pest Risk Analysis (PRA) Advances in Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

UNIT II : Advances in the cause and establishment of disease in seed and seedling. Advances in 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. Advances in influence of epidemiological factors influencing the transmission of seed-borne diseases, computer model based forecasting of epidemics through seed-borne infection.

UNIT IV : Advances in 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 : Advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses. Relationship between seed-borne infection and expression of the disease in the field/ orchards.

Suggested References

Agarwal V.K., 2006, Seed Health, IBDCO Publication, New Delhi.

Agarwal VK & JB Sinclair. 1993. Principles of Seed Pathology. Vols. I & II, CBS Publ., New Delhi.

Hutchins JD & Reeves JE. (Eds.). 1997. Seed Health Testing: Progress Towards the 21st Century. CABI, Wallington.

Paul Neergaard. 1988. Seed Pathology. MacMillan, London.

Suryanarayana D. 1978. Seed Pathology. Vikash Publ., New Delhi.

HPP 614 ADVANCES IN EPIDEMIOLOGY FORECASTING AND LOSS ASSESSMENT OF PLANT DISEASES (1+1)

Theory

UNIT I : Advances in epidemic concept, pathometry and crop growth stages, epidemic growth and analysis, systems approach in epidemiology

UNIT II : Advances in common and natural logrithms, function fitting area under disease progress curve and correction factors, inoculum dynamics, population biology of pathogens, temporal spatial variability in plant pathogens, modeling of epidemics.

UNIT III : Advances in conducting survey, surveillance and vigilance, crop loss assessment and models.

UNIT IV : Advanced concepts in understanding 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 : Advanced techniques in measuring diseases, spore dispersal and trapping, weather recording, survey, multiplication of inoculum, inoculation techniques, computerized data analysis, function fitting, model preparation and validation

Suggested References

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.

HPP 615 ADVANCES IN BIOLOGICAL MANAGEMENT OF PLANT DISEASES (1+1)

Theory

UNIT I

Modern concepts of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological management.

UNIT II : Advances in mechanisms involved in biological interactions, competition, mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological management.

UNIT III : Advances in understanding factors governing biological management, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological management 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 among different bioagents as well as with other fungistatic compounds.

UNIT IV : Modern concepts and advances in 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 : Advanced methodology for 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.

Suggested References

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.

HPP 616 ADVANCES IN DISEASE RESISTANCE IN PLANTS (1+1)

Theory

UNIT I : Advances in dynamics of pathogenicity, process of infection, invasion colonization, variability in plant pathogens, sources of resistance, Modern concepts and terminologies in disease resistance.

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.

Practical : Detection of plant morphological structures associated with resistance, Detection and estimation of preformed and post inflectional defence mechanism associated with major plant diseases.

Suggested References

Deverall BJ. 1977. Defence Mechanisms in Plants. Cambridge Univ. Press, Cambridge, NewYork.

Mills Dallice et al.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.

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PLANT PATHOLOGY

List of Journals

- Annals of Applied Biology – Cambridge University Press, London
- Annual Review of Phytopathology – Annual Reviews, Palo Alto, California
- Annual Review of Plant Pathology - Scientific Publishers, Jodhpur
- Canadian Journal of Plant Pathology - Canadian Phytopathological Society, Ottawa
- Indian Journal of Biotechnology - National Institute of Science Communication and Information Resources, CSIR, New Delhi
- Indian Journal of Mycopathological Research- Indian Society of Mycology, Kolkata.
- Indian Journal of Virology - Indian Virological Society, New Delhi
- Indian Phytopathology - Indian Phytopathological Society, New Delhi
- Journal of Mycology and Plant Pathology - Society of Mycology and Plant Pathology, Udaipur
- Journal of Phytopathology - Blackwell Verlag, Berlin
- Mycologia - New York Botanical Garden, Pennsylvania
- Mycological Research - Cambridge University Press, London
- Physiological Molecular Plant Pathology - Academic Press, London
- Phytopathology - American Phytopathological Society, USA
- Plant Disease - The American Phytopathological Society, USA
- Plant Disease Research – Indian Society of Plant Pathologists, Ludhiana
- Plant Pathology - British Society for Plant Pathology, Blackwell Publ.
- Review of Plant Pathology - CAB International, Wallingford
- Virology- Academic Press New York

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- www.shopapspress.org
- www.apsjournals.apsnet.org
- www.apsnet.org/journals
- www.cabi_publishing.org
- www.springer.com/life+Sci/agriculture
- www.backwellpublishing.com
- www.csiro.au
- www.annual-reviews.org

Suggested Broad Topics for Doctoral Research

- Molecular tools in disease diagnosis
- Molecular mechanisms of pathogenesis in crops and seeds
- Transgenic resistance
- Induction of resistance using biotic and abiotic elicitors
- Pathogenesis and characterization of plant pathogens
- Survey and surveillance
- Variability in plant pathogens
- Plant-Virus-Vector relationships
- Genome organization of plant pathogens
- Dynamics of plant pathogen propagules and their biology
- Development of disease prediction models in disease forecasting
- Integrated Disease Management
- Molecular Taxonomy of different plant pathogens
- Development of Rapid Diagnostic methods
- Development and Formulation of Improved Biocontrol Agent

Ph.D. ENTOMOLOGY

CORE COURSES

Course No.	Course No.	Credits
HET 601	Advances in Insect Systematics	1+2
HET 602	Immature stages of Insects	1+1
HET 603	Advances in Insect Physiology	1+1
HET 604	Advances in Insect Ecology	1+1
HET 605	Advances in Insecticide Toxicology	1+1
HET 606	Recent Trends in Biological Control	1+1
HET 607	Advances in IPM in Horticulture Ecosystem	2+0
	TOTAL	8+7=15

OPTIONAL COURSES

Course No.	Course No.	Credits
HET 608	Insect Behavior	1+1
HET 609	Advances in Host plant Resistance in Horticulture crops	1+1
HET 610	Advances in Acarology	1+1
HET 611	Horticulture Ornithology	1+1
HET 612	Molecular Approaches in Entomological Research	1+1
HET 613	Plant Biosecurity and Biosafety	1+1
HET 614	Ecology and Biology of Soil arthropods and their management	1+1
HET 615	Forest Entomology- Ecology and Management	1+1
HET 616	Advances in Insect Pathology	1+1
	TOTAL	18

OTHERS

Course No.	Course No.	Credits
HET 671	Qualifying Examination	04
HET 681	Seminar	04
HET 691	Research	39
	TOTAL	

CORE COURSES

HET 601 Advances in Insect Systematics (1+2)

Theory : Detailed study of three schools of insect 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 speciation processes and evidences, Zoogeography, 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. Detailed study of International Code of Zoological Nomenclature, including appendices to ICZN-Ethics. 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.

Practicals : 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 diagrams, and preparation of specimens for "type like" preservation. Submission of the collections made out of the group. Multivariate analysis techniques for clustering specimens into different taxa and development of phenograms. Rooting and character polarization 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 and Whitten MA. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer-Verlag, Berlin.

Embden HFV. 2013. Handbook of Agricultural Entomology. Wiley Blackwell. USA.

Freeman S and 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 and Ashlock PD. 1991. Principles of Systematic Zoology, 2nd Ed. Mc Graw 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.

Richards and Davies. 1977. Imm's general textbook of entomology. Volume 2. B. I. Publications Pvt Ltd, New Delhi.

Ross HH. 1974. Biological Systematics. Addison Wesley Publ. Co., London.

Triplehorn and Johnson. 2005. Borror and Delong's introduction to the study of insects. Brooks/Cole. California. USA.

Wiley EO. 1981. Phylogenetics: The Theory and Practices of Phylogenetic Systematics for Biologists. Columbia Univ. Press, USA.

HET 602 Immature Stages of Insects (1+1)

Theory : Types of immature stages of insect orders, morphology of egg, nymph/larva and pupa, identification of different immature stages of insect pests infesting crops and stored products. Comparative study of life history strategies in hemi-metabola and holo-metabola, immature stages as ecological and evolutionary adaptations, Significance of immature stages in pest management.

Practicals : Types of immature stages; their collection, rearing and preservation. Identification and classification of immature insects to orders and families in exopterygote orders viz., Orthoptera, Hemiptera, and endopterygote orders viz., Diptera ,Lepidoptera, Hymenoptera and Coleoptera using keys.

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.

HET 603 Advances in Insect Physiology (1+1)

Theory : Physiology and biochemistry of insect cuticle and moulting process. Biosynthesis of chitin, chitin-protein interactions in various cuticles, types of sclerotization. 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 the growth and development; physiology of excretion and osmoregulation, water conservation mechanisms. 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. Endocrine system and insect hormones, physiology of insect growth and development-metamorphosis, polyphenism and diapause. Energetics of muscle contractions.

Practical : Estimation of chitin in insect cuticle, amino acids in haemolymph. Characterization and enumeration of blood cells. Purification, quantification and bioassay of juvenile and moulting hormones. Estimation of gut enzymes in predaceous and phytophagous insects. Extraction, isolation of sex pheromones and measuring its beharvioural response in insects. Extraction, culturing and identification of gut microflora/ symbionts in termites and scaribids.

Suggested Readings

Awasthi VB. 1977. Introduction to general and applied entomology. Scientific Publishers. Jodhpur.

Awasthi VB. 2005. Insect Neuroendocrines. Scientific Publishers. Jodhpur.

Gullan and Cranston. 1994. The insects- an outline of entomology. Wiley Blackwell. USA.

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.

Richards and Davies. 1977. Imm's general textbook of entomology. Volume 1. B. I. Publications Pvt Ltd, New Delhi.

HET 604 Advances in Insect Ecology (1+1)

Theory : Characterization of distribution of insects – Indices of Dispersion, Taylor's Power law. Island Biogeography. Population dynamics –Life tables, Leslie Martix, stable age distribution, Population projections. Predator-

prey models- Lotka- Volterra and Nicholson-Bailey Model. Crop Modeling - an introduction. Insect Plant Interactions. Fig-fig wasp mutualism and a quantitative view of types of associations. Role of insects in the environment. Adaptation 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 insects 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 defences. 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. Reproductive Ecology– sexual selection, mating systems, Reproductive strategies- timing, egg number, reproductive effort, sibling rivalry and parent-offspring conflict. Agro-ecological vs Natural Ecosystems- Characterization, Pest Control as applied ecology- case studies.

Practicals : 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 applications of Leslie Matrix – Population projections, Stable age distribution. Exercises in development of Algorithms for crop modeling.

Suggested Readings

Agarwal ML. 2009. Perspectives in Insect behaviour. International book distributing co. Lucknow.

Awasthi VB. 1977. Introduction to general and applied entomology. Scientific Publishers. Jodhpur.

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.

Fellowes MDE, Hollower GJ and Rolff J. 2005. Insect evolutionary ecology. CABI.

Freeman S & Herron JC.1998. Evolutionary Analysis. Prentice Hall, New Delhi.

Frost SW. 1994. General entomology. Narendra Publishing house. 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.

Ignacimuthu S and Jayaraj S. 2006. Biodiversity and insect pest management. Narora Publishing house. New Delhi.

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.

Price PW, Denno RF, Eubanks MD, Finke DL and Kaplan I. 2013. Insect ecology-Behaviour, Populations and Communities. Cambridge University Press.

Real LA and 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.

HET 605 Advances in Insecticide Toxicology (1+1)

Theory : Penetration and distribution of insecticides in insect systems; insecticide selectivity; factors affecting toxicity of insecticides. Biochemical and physiological target sites of insecticides in insects; recent developments in biorationals, biopesticides, nanopesticides and newer molecules; their modes of action and structural – activity relationships; advances in metabolism of insecticides. Joint action of insecticides; activation, synergism and potentiation. Factors responsible for insecticide property deactivation. Problems associated with pesticide use in agriculture:

pesticide resistance, resistance mechanisms and resistant management strategies; pest resurgence and outbreaks; pesticides persistence and pollution; health hazards and other side effects. Estimation of insecticidal residues – sampling, extraction, clean-up and estimation by various methods; maximum residue limits (MRLs) and their fixation; insecticide laws and standards and good agricultural practices.

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 Reference

Busvine JR. 1971. A Critical Review on the Techniques for Testing Insecticides. CABI, London.

Brooks. G.T and Roberts, T.R (Ed) 1999. Pesticide Chemistry and Biosciences. In Food Environment challenge. Royal society of Chemistry. UK

Das. K.G. 1981. Pesticide Analysis. New York Marcel Dekker Inc. New York.

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.

Hayes A.W and Tailor Fraus, (Eds) 2001. Principles and Methods of Toxicology, Philadelphia.

Ignacimuthu S and David BV. 2009. Ecofriendly insect pest management. Elite publishing house Pvt Ltd. New Delhi.

Ishaaya I & Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.

Larry PP, Marlin and Rice E. 2009. Entomology and pest management. Pearson Prentice hall.

Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York.

Matthews GA, Bateman R and Miller P. 2014. Pesticide application methods. Wiley Blackwell.

Mayer M.S and Mc Laughlin J.R 1990. Insect pheromones and sex attractants CRC press, Boca Rato.

O' Brien RD. 1974. Insecticides Action and Metabolism. Academic Press, New York.

Parmar BS and Tomar SS. 2004. Pesticide formulation. CBS publishers and distributers. New Delhi.

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.

Sharma KK. 2007. Pesticide residue analysis manual. Directorate of Information and Publications of agriculture. New Delhi.

Soloneski S and Larramendy M. 2014. Insecticides. Intech.

Stoytcheva M. 2014. Pesticides in the modern world. Intech.

Valkenburg WV, Sugavanam B and Khetan SK. 2008. Pesticide formulations. New age international (P) Ltd. New Delhi.

HET 606 Recent Trends in Biological Control (1+1)

Theory : 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. Mass culturing techniques, insectary facilities and equipments, basic standards of insectary, viable mass-production unit, designs, precautions, good insectary practices. Colonization, techniques of release of natural enemies, recovery evaluation, conservation and augmentation of natural enemies, survivorship analysis and ecological manipulations, mass production of bicontrol agents, bankable project preparation. 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.

Practicals : 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 Reference

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.

Gautam RD. 2008. Biological pest suppression. Westville Publishing house. 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.

Ignacimuthu S and David BV. 2009. Ecofriendly insect pest management. Elite publishing house Pvt Ltd. New Delhi.

Koul O and Cuperus GW. 2007. Ecologically based integrated pest management. CABI.

Koul O, Dhaliwal GS, Marwala SS and Arora JK.2012. Biopesticides and pest management. Campus Books International. New Delhi.

Larry PP, Marlin and Rice E. 2009. Entomology and pest management. Pearson Prentice hall.

Narayanasamy P. 2010. Organic pest management. Satish serial publishing house. Delhi.

Reddy PP. 2010. Insect, mites and vertebrate pests and their management in horticultural crops. Scientific Publishers. Jodhpur.

Stock SP, Vandenberg J, Glaza I and Boemare N. 2009. Insect pathogens-molecular approaches and techniques. CABI.

Stoytcheva M. 2014. Pesticides in the modern world. Intech.

HET 607 Advances in Integrated Pest Management in Horticulture Ecosystem (2+0)

Theory : Principles of sampling and surveillance; database management and computer programming, simulation techniques and system analysis and modeling. Case histories of national and international programmes, their implementation, adoption and criticisms, global trade and risk of invasive pests. 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. 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 Reference

Aluja M, Leskey TC and Vincente. 2009. Biorational Tree fruit pest management. CABI.

Atwal AS and Dhaliwal GS. 2009. Agricultural pests of south Asia and their management. Kalyani publishers. Ludhiana.

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.

Heather NW and Haldman GJ. 2008. Pest management and phytosanitory trade barriers. CABI.

Ignacimuthu S and Jayaraj S. 2006. Biodiversity and insect pest management. Narora Publishing house. New Delhi.

Koul O, Cuperus GW and Elliot N. 2008. Areawide pest management. CABI.

Koul O & Cuperus GW. 2007. Ecologically Based Integrated PestManagement. CABI, London.

Koul O, Dhaliwal GS & Curperus GW. 2004. Integrated Pest Management - Potential, Constraints and Challenges. CABI, London.

Larramendy ML and Soloneske S. 2014. Integrated Pest Management and Pest control. Intech.

Larry PP, Marlin and Rice E. 2009. Entomology and pest management. Pearson Prentice hall.

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.

Narayanasamy P. 2010. Organic pest management. Satish serial publishing house. Delhi.

Norris RF, Caswell-Chen EP & Kogan M. 2002. Concept in Integrated Pest Management. Prentice Hall, New Delhi.

Oakeshott J & Whitten MA. 1994. Molecular Approaches to Fundamental and Applied Entomology.

Springer Verlag. 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.

Rao V, Umamaheswari, Prasad R, Naidu and Savithri. 2003. Integrated insect pest management. Agrobios India. Jodhpur.

Rechcigl JE & Rechcigl NA. 1998. Biological and Biotechnological Control of Insect Pests. Lewis Publ., North Carolina.

Reddy PP. 2010. Insect, mites and vertebrate pests and their management in horticultural crops. Scientific Publishers. Jodhpur.

OPTIONAL COURSES

HET 608 Insect Behaviour (1+1)

Theory : 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, Behaviour traits under natural selection, genetic control of behaviour and behavioural polymorphism. Orientation – Forms of primary and secondary orientation including taxis and kinesis;

Communication – primary and secondary orientation, responses to environment stimuli, role of visual, olfactory and auditory signals in inter- and intra-specific communication, use of signals in defense, mimicry, polyphenism; evolution of signals. Reproductive behavior- mate finding, courtship, territoriality, parental care, parental investment, sexual selection and evolution of sex ratios; Social behavior – kin selection, parental manipulation and mutualism; Self organization and insect behavior. Foraging – Role of different signals in host searching (plant and insects) and host acceptance, ovipositional behavior, pollination behavior, coevolution of plants and insect pollinators. Behavior 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.

Practicals : Quantitative methods in sampling behavior; 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 Reference

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.

Kuzman H. 2010. General textbook of entomology. Apple academics. Oakville.

Krebs JR & Davies NB. 1993,An Introduction to Behavioural Ecology. 3 rd 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.

HET 609 Advances in Host Plant Resistance in Horticulture crops (1+1)

Theory : Importance of plant resistance, historical perspective, desirable morphological, anatomical adaptations of resistance, assembly of plant species- gene pool; insect sources- behavior in relation to host plant factors. 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. 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. 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.

Practicals : Understanding mechanisms of resistance for orientation, feeding, ovipostion 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 and plant resistance index.

Suggested Reference

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.

Dhaliwal GS and Singh P. 2005. Host plant resistance to Insect. Panima Publishing corporation. New Delhi.

Koul O and Cuperus GW. 2007. Ecologically based integrated pest management. CABI.

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.

HET 610 Advances in Acarology (1+1)

Theory : 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 fromfamilies Tetranychidae, Tenuipalpidae, Eriophyiidae, Tarsonemidae, Phytoseiidae, Bdellidae, Cunaxidae, Stigmaeidae, Pymotidae, Cheyletidae, Acaridae, Pyroglyphidae, Orthogalumnidae, Argasidae, Ixodidae, Sarcoptidae. Soil mites in India. Management of economically important species of mites in agriculture, veterinary and public health; storage acarology. 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. Predatory mites, their mass production and utilization in managing mite pests, acaropathogenic fungi-Identification, isolation and utilization.

Practicals : 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 Reference

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.

Gerson V, Smiley RL and Ochoa R. 2003. Mites for pest control. Blackwell Science.

Zhung ZQ. 2007. Mites of green houses. CABI.

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.

HET 611 Horticuture Ornithology (1+1)

Theory : Status of agricultural ornithology in India, groups of birds associated with agro -ecosystems. Habitat association 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. Nature of damage caused by birds in different crops. Foraging ecology of birds in agricultural fields. Beneficial role of carnivorous birds in agriculture and attracting them to field. Use of bird excreta in agriculture. Management of bird pests in agriculture by various methods.

Practicals : Study of different groups of birds associated with agriculture and horticulture crops, their morphology and field identification. Field visits to different Horticulture eosystems. 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 gardens/ orchards. Analysis and study of the use of bird excreta in agriculture at a bird sanctuary. Field visits to various horticulture ecosystems to study birds in crop fields. Assignments on assessing bird damage, estimation of populations etc.

Suggested Reference

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.

HET 612 Molecular Approaches in Entomological Research (1+1)

Theory : Introduction to molecular biology; techniques used in molecular biology. 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 entomopthogenic fungi. Genes of interest in entomological research – marker genes for sex identification, neuropeptides, JH esterase, Bt toxin and venoms, chitinase, CPTI; lectins and proteases. Transgenic plants for pest resistance and diseases. 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 inherit tolerance of natural enemies. 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.

Practicals : Isolation of DNA/RNA; purity determinations; base pair estimation; agarose gel electrophoresis; restriction mapping of DNA; demonstration of PCR, RFLP and RAPD techniques.

Suggested Reference

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.

Koul O, Dhaliwal GS, Marwala SS and Arora JK.2012. Biopesticides and pest management. Campus Books International. New Delhi.

Oakeshott J & Whitten MA.. 1994. Molecular Approaches to Fundamental and Applied Entomology.

Rivers DB and Dahlem GA. 2014. The science of forensic entomology. Wiley Blackwell. USA.

Roy U & Saxena V. 2007. A Hand Book of Genetic Engineering. 1st Ed., Kalyani Publ., New Delhi.

Sharma HC. Biotechnological approaches for pest management and ecological sustainability. CRC press. New York.

Springer Verlag. Rechcigl JE & Rechcigl NA. 1998. Biological and Biotechnological Control of Insect Pests. Lewis Publ., North Carolina.

Singh BD. 2008. Biotechnology (Expanding Horizons). Kalyani Publ., New Delhi. Singh P. 2007. Introductory to Biotechnology. 2nd Ed. Kalyani Publ., New Delhi.

Stock SP, Vandenberg J, Glaza I and Boemare N. 2009. Insect pathogens-molecular approaches and techniques. CABI.

Stoytcheva M. 2014. Pesticides in the modern world. Intech.

HET 613 Plant Biosecurity and Biosafety (2+0)

Theory : History of biosecurity, Concept of biosecurity, Components of biosecurity, Quarantine, Invasive Alien Species, Bio-warfare, Emerging/ resurgence of pests and diseases. 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, environmental impact analysis and 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. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, Issues related to release of genetically modified crops.

Suggest Reference

FAO Biosecurity Toolkit 2008. www.fao.org/docrep/010/a1140e/a1140e00.htm Laboratory Biosecurity Guidance.
http://www.who.int/csr/resources/publications/biosafety/WHO_CDS_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
Matthews GA, Bateman R and Miller P. 2014. Pesticide application methods. Wiley Blackwell.
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-
Biosecurity for Agriculture and Food Production. http://www.fao.org/biosecurity/
CFIA.http://www.inspection.gc.ca/english/anima/heasan/fad/biosecure.sht Ml

HET 614 Ecology and Biology of soil arthropods and their management (1+1)

Theory : History of soil biology. Advantages and disadvantages of soil and habitat for invertebrates. Role of soil physico-chemical properties on the distribution of soil arthropods. Classification of soil arthropods, habits and identification. Assessment of arthropods population in soil and litter sampling and extraction methods. Biology, ecology and behaviour of soil arthropods. Factors affecting distribution of soil arthropods. Role of soil arthropods in litter decomposition and sustainability. Inter – relationship among soil arthropods and soil microbes. Impact of soil arthropods activities on the soil properties. Effects of agricultural practices on the soil arthropods. Soil arthropods as bio – indicators of soil health.

Practicals : Study of relation between physico- chemical properties of soils and soil arthropod abundance and diversity. Identification of soil arthropods, methods of soil and litter sampling for arthropods. Methods of extraction of soil arthropods. Role of arthropods in litter decomposition. Effects of agro- chemicals on soil arthropods. Assignments and small group projects.

Suggested Reference

Anderson J.M and Ingram JSI. 1993. Tropical Soil Biology and Fertility: A Handbook of Methods. CABI, London.

Dindal D.L. 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 G. K and Rajagopal., D. 1988. Applied Soil Biology and Ecology. Oxford & IBH Publ., New Delhi.

HET 615 Forest Entomology – Ecology and Management (1+1)

Theory : Population dynamics of forest trees in relation to phytophagous insects. Effects of phytophagous insects in forest ecosystem. History and importance of forest entomology in India. Classification of forest insect pests. Factors responsible for outbreak of forest pests. Survey methodology for forest pests. Bio- ecology, nature of damage, distribution and management strategies of important insect pests of timber and fruit yielding species. (Ber, Jack, Jamun) of natural forests and plantation (Teak, Ailanthus, Neem, Eucalyptus, Subabul, Bamboo, Sal, Terminalia, Dalbergia, Albizia, Casuarina, Pterocarpus, Acacia Sp., Sandal, Butea, Pongamia, Deodar, etc.) Timber pests and their management. Insects induced deformities, malformations and plant galls in forest trees. Non insect pests of forest trees. Infestation of forest seeds by insect pests. Principles and concepts. Forest pest management – silvicultural control, biological control, microbial control and IPM.

Practicals : Study of insect damage under forest ecosystem. Identification of immature and adult stages of important insect pests of timber and fruit yielding species (Ber, Jamun, Jack etc) of natural forests and plantations (Teak, Ailanthus, Neem, Eucalyptus, Subabul, Bamboo, Sal, Terminalia, Dalbergia, Albizia, Casuarina, Pterocarpus, Acacia Sp., Sandal, Butea, Pongamia, etc.). Non- insect pests and forest nursery pests. Each student has to collect and submit 50 insect pest species of forest plants/trees. Assignments and small group projects.

HET 616 Advances in Insect Pathology (1+1)

Theory : Scope and current status of insect pathology, Virulence, infection and Epizootiology, Resistance and immunity, infection and epizootiology, symptamatology and pathologies of diseases in insects caused by Bacteria, Fungi, Viruses, Protozoa, rickettssia, spiroplasma and nematodes. Defense mechanism in insects to entomopathogens. Diseases of productive and beneficial insects, interactions between Entomopathogens and insects, microbial pesticides. Genetic improvement of entomopathogens. Use of biotechnological tools in insect pathology. Requirements for registering microbial pesticides.

Practicals : Study of different diseases of insects caused by fungi, bacteria and viruses. Using keys for identification of micro–organisms infecting insects. Study of mass multiplication techniques. Study of different diseases of productive and beneficial insects.

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.

Stock SP, Vandenberg J, Glaza I and Boemare N. 2009. Insect pathogens-molecular approaches and techniques. CABI.

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NEW AND RESTRUCTURED Ph. D. CURRICULA AND SYLLABI

Ph.D Programme (Biotechnology and Crop Improvement)

Courses	Credit hours
Major courses	15
Minor course	8
Supporting course	5
Seminar	4
Comprehensive examination	4
Research	39
Non Credit Compulsory	3
Total	75 + 3

Course structure

Course No.	Course Details	Credits
BCI 601	Advances in Plant Breeding Systems	2+0
BCI 602	Advanced biometrical and quantitative Genetics	2+1
BCI 603	Advances in Plant Molecular Biology	2+0
BCI 604	Advances in Genetic Engineering	2+1
BCI 605	Advances in functional genomics and proteomics	2+0
BCI 606	Emerging trends in seed quality enhancement	2+1
	TOTAL	15

Optional Courses

Course No.	Course Details	Credits
BCI 607	Plant genetic resources and pre-breeding	2+0
BCI 608	Intellectual property rights and biosafety in plant breeding	2+0
BCI 609	Crop evolution	2+0
BCI 610	Breeding of designer crops	2+1
BCI 611	Advances in breeding of major horticulture crops	3+0
BCI 612	Marker development and gene mapping	1+1
BCI 613	Advances in crop biotechnology	2+1
BCI 614	Commercial plant tissue culture	1+1
BCI 615	Advances in Seed Science Research	3+0
BCI 616	Commercial biotechnology	2+0

Cont....

Course No.	Course Details	Credits
BCI 617	Seed processing and storage	2+1
BCI 618	Seed quality testing	2+1
BCI 619	Seed storage and deterioration	1+1
BCI 620	Testing for genuineness & purity of cultivars	1+1
BCI 621	DUS testing for plant variety protection	2+1
BCI 622	Hybrid Seed Production	2+0

* Core Courses

BCI 601* Advances in Plant Breeding Systems (2+0)

Theory : Chromosomal study-karyotype, banding techniques, Plant breeding before and after the discovery of Mendelism; Flower development and its importance; genes governing the whorl formation and various models proposed; Case Studies of Mating systems and their exploitation in crop breeding; Types of pollination, mechanisms promoting cross pollination. Self- Heterosis and its exploitation by self incompatability and male sterility - Types of self incompatability: Homomorphic (sporophytic and gametophytic) and heteromorphic - Breakdown of incompatibility Floral adaptive mechanisms - Spatial and temporal - Genetic and biochemical basis of self incompatibility; Sterility: male and female sterility - Types of male sterility: GMS, CMS, CGMS, Two-Line, One-Line breeding and others; Exploitation in monocots and dicots, uses and difficulties in exploiting CGMS system in dicots - Case studies and breeding strategies; Genetic , biochemical and molecular bases of heterosis. Prospects and problems - Conversion of agronomically ideal genotypes into male steriles - Concepts and breeding strategies; Case studies Influence on their expression, genetic studies; Principles and procedures in the formation of a complex population; Types of populations - Mendelian population, gene pool, composites, synthetics etc.; Genetic basis of population improvement. Selection in self-fertilizing crops; Selection in cross fertilizing crops -Polycross and topcross selections, Mass and recurrent selection methods and their modifications, ear to row selection, modified ear to row selection; Convergent selection, divergent selection;. Selection in clonally propagated crops.

References:

Allard, R.W., 1966, Principles of Plant Breeding. John Wiley & Sons.
Fehr WR. 1987. Principles of Cultivar Development: Theory and Technique. Vol I. Macmillan.
Simmonds, N.W., 1979, Principles of Crop Improvement. Longman.
Singh, B.D., 1997, Plant Breeding: Principles and Methods. 5th Ed., Kalyani.
Welsh, J.R., 1981, Fundamentals of Plant Genetics and Breeding. John Wiley.

BCI – 602* Advances in Biometrical and Quantitative Genetics (2+1)

Theory : 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. Models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction(AMMI) analysis and other related models; Principal Component Analysis. Additive and multiplicative model - Shifted multiplicative model; Analysis and selection of genotypes; Methods and steps to select the best model - Biplots and mapping genotypes. Genetic architecture of quantitative traits; Conventional analyses to detect gene actions - Partitioning of phenotypic/genotypic variance –Models-Line x Tester, Diallel, triallel, quadric allele, Partial diallel, biparental matings, heritability, genetic gain 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, Quadriallel analysis,Triple Test Cross (TTC). 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 gene-tagging and QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies. Use of softwares in biometric analysis.

References:

Falconer, D.S. and Mackay, J., 1996, Introduction to Quantitative Genetics. Longman.

Mather, K. and Jinks, L., 1983, Introduction to Biometrical Genetics. Chapman & Hall.

Nadarajan, N. and Gunasekaran, M., 2005, Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani.

Singh, P. and Narayanan, S.S., 1993, Biometrical Techniques in Plant Breeding. Kalyani.

Singh, R.K. and Choudhary, B.D., 1987, Biometrical Methods in Quantitative Genetics. Kalyani.

Wricke, G. and Weber, W.E., 1986, Quantitative Genetics and Selection in Plant Breeding. Walter de Gruyter.

BCI 603* Advances in Plant Molecular Biology (2+0)

Theory: Generation of various types of molecular markers. Development of Mapping Populations,-biparental mapping and Association mapping. Gene tagging and QTL mapping.Marker Assisted selection (MAS). Arabidopsis in molecular biology, molecular perspective of plant embyo-development; Forward and reverse genetic approaches; TILLING & ECOTILLING Transcriptional and post transcriptional regulation of gene expression; Isolation of promoters and other regulatory elements; RNA interference, transcriptional gene silencing, Transcript and protein analysis, advances in transcript profiling approaches such as ESTs, Fl_cDNAs, 3' and 5'SAGE and NGS systems to study biological mechanisms; Small RNA biology-microRNAs, tasiRANs, siRNAs etc. and their role in plant biological mechanisms. Hormone regulatory pathways: ethylene, cytokinin, auxin and ABA, SA; ABC model of floral development; Molecular basis of self-incompatibility, Regulation of flowering: photoperiod, vernalization, circadian rhythms. Molecular biology of abiotic stress responses: cold and high temperature, submergence, 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 defence. Transcriptimoics, proteomics and metabolomic approaches. In-situ hybridization for locating genes on chromosomes. Comparative genomics

References:

Molecular biology of gene Watson, Baker, Bell, Gann, Levin, Losick
Molecular biology of the cell Alberts, Johnson, Lewis, Raff, Raff, Roberts, Walter.
Molecular Cell Biology Harvey Lodish , Arnold Berk, Paul Matsudaira , Chris A. Kaiser , Monty Krieger, Matthew P. Scott , Lawrence Zipursky , James Darnell.
"Molecular Cell Biology" Darnell J, Lodish H, Baltimore D
Molecular Biology of the Cell Alexander Johnson, Bruce Alberts, Dennis Bray, Julian Lewis, Keith Roberts, and Martin Raff

BCI 604* Advances in Genetic Engineering (2+1)

Theory : General overview of transgenic plants: case studies - genetic engineering of herbicide resistance, transgenic plants resistant to insect/ pests, genetic engineering of abiotic stress tolerance, engineering food crops for quality, genetically engineered pollination control, induction of male

sterility in plants. 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. 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. 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.

Practical : Isolation of Ti plasmid, construction of recombinant Ti plasmid, transformation, transfer through other methods; detection of transgene by PCR; Expression of reporter genes, expression of marker genes, confirmation of the expression by southern and northern blot analysis; Detection of the proteins produced by SDS analysis and western analysis; Bioassay of the proteins if the reporter gene is an enzyme like GUS & Lac Z; UV visualization for GFP.

References:

Lisa Yount Biotechnology and Genetic Engineering.
Desmond S. T. Nicholl An introduction to genetic engineering
Kathy Wilson Peacock Biotechnology and Genetic Engineering
Oliver Brandenberg Zephaniah Dhlamini Alessandra SensiKakoliGhosh Andrea Sonnino Introduction to Molecular Biology and Genetic Engineering
Iain E. P. Taylor Genetically engineered crops Interim, policies, uncertain legislation

BCI-605* Advances in functional genomics and proteomics (2+0)

Theory: Genome sequencing and functional genomics; Human, plant, bacterial and yeast genome projects; genome annotation; ab initio gene discovery; functional annotation and gene family clusters; etc. Functional analysis of genes; RNA-mediated interference; gene knockoffs; Gene traps/ TDNA and transposable element insertion / activation lines, trans activation lines; homologous recombination; microarray profiling; SAGE; SNPs/ variation; yeast-two hybrid screening; gene expression and transcript profiling; EST contigs; TILLING & EcoTILLING; allele/gene mining; synteny and comparative genomics; Genome evolution, speciation and domestication etc. 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. Discussion on selected papers on functional genomics, proteomics, integrative genomics, Metabolomics approaches etc

References:

Stagljar, Igor (Ed.) Yeast Functional Genomics and Proteomics, Methods and protocol

Marc R. Wilkins Proteome Research: New Frontiers in Functional Genomics

Kaufmann, Michael, Klinger, Claudia (Eds.)Functional Genomics Methods and Protocols

Krebs JK, Lewin B Genes XI , published by Jones and Barlett Watson JD, Bakee TA, Bell SP, Gann A, Levine M &Losick R. 2008 Molecular Biology of the Gene. 6th Ed. Pearson Education International.

BCI 606* Emerging trends in Seed Quality Enhancement (2+1)

Theory : 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.

Seed priming: physiological and biochemical basis, types of priming technology, biochemical and molecular changes associated, pre germination, film coating and pelleting, seed tapes, seed mats, seed colouring, biopriming.

Synthetic seeds – Aim and scope for synthetic seeds, historical development, somatic embryogenesis, somaclonal variation and their control, embryo encapsulation systems, hardening of artificial seeds, cryopreservation, storage of artificial seeds, descication 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.

References:

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.
Singhal NC. 2003. Hybrid Seed Production in Field Crops. Kalyani.

Thompson JR. 1979. An Introduction to Seed Technology. Leonard Hill.

BCI 607 Plant Genetic Resources and Pre-breeding (2+0)

Theory: 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. 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. 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. 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. 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. 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. Post-genomic tools for genetic enhancement of germplasm; Pre-breeding through chromosome manipulation; Application of biotechnology for Genetic enhancement-Achievements. Use of molecular marker systems in fingerprinting and maintaining plant genetic resources. Utilization of genetic resources, concept of core and mini-core

collections, genetic enchancement / Prebreeding for crop improvement including hybrid development.

References:

Frankel, O.H. and Bennett, E., 1970, Genetic Resources in Plants – their Exploration and Conservation. Blackwell.

Gautam, P.L., Dass, B.S., Srivastava, U. and Duhoon, S.S., 1998, Plant Germplasm Collecting: Principles and Procedures. NBPGR, New Delhi.

Painting, K.A., Perry, M.C., Denning, R.A. and Ayad, WG., 1993, Guide Book for Genetic Resources Documentation. IPGRI, Rome, Italy.

Paroda, R.S. and Arora, R.K., 1991, Plant Genetic Resources, Conservation and Management. Concepts and Approaches. IPGRI Regional office for South and South Asia, New Delhi.

BCI 608 Intellectual Property Rights and Biosafety in Plant Breeding (2+0)

Theory :IPR regimes under TRIPS; Plant Breeder Rights and Patents for crop varieties; IPR under CBD, PGRs and Sui-generis system ; Current status of Plant Variety Protection in different countries and existing scenario in India; Plant Variety Protection and Farmer's Right Act 2001 .and Rules 2003 ; Farmer's Right on Indigenous Knowledge, ;Conservation and Benefit sharing; Material Transfer Agreements and procedure for filing of patents in India ; Patent Convention Treaty; Transgenics - their handling by public and private Institutes; Protocols to be followed under DBT guidelines, infrastructure needed; Regulatory issues; Cartagena protocols; Risk assessment for development of resistance in pests; Toxicological aspects, gene escape, GURTS and Bioethics.

BCI – 609 Crop Evolution (2+0)

Theory : 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. Domestication and uniformity – Characteristics of early domestication and changes – Conceptof gene pools and crop evolution; molecular phyllogenetic study of evolution of crop spp. Selection and Genetic drift - Consequences. Speciation and domestication – The process of speciation – Reproductive isolation barriers –Genetic differentiation during speciation – Hybridization - speciation and extinction. 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. 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. 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. 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 Vegetables, Fruit crops, Flower crops, Plantation crops, Tuber crops and Medicinal Plants.

References:

J. F. Hanccock, Crop Evolution, Adaptation and Yield

Lloyd T. Evans, Plant Evolution under Domestication

Gideon Ladizinsky, Evolution of Crop Plants

Cynthia Perez, Gene Pool Diversity and Crop Improvement

BCI – 610 Breeding of Designer crops (2+1)

Theory : 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. 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 and its significance in crop improvement. 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. 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. Biosafety management, segregation and isolation requirements in designer

crop production and post-harvest management. Strategies in breeding by design

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. Starch, protein, sugars, alkaloids estimation methods.

References:

Balint, A., 1984, Physiological Genetics of Agricultural Crops. AK Ademiaikiado.

Hay, R.K., 2006, Physiology of Crop Yield. 2nd Ed. Blackwell.

Pessarakli, M., 1995, Handbook of Plant and Crop Physiology. Marcel Dekker.

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

BCI - 611 Advances in Breeding of major horticultural crops (3+0)

Theory : History, description, classification, origin and phylogenetic relationship, genome status in cultivated and alien species of major vegetables and fruit and flower crops. Breeding objectives in Tomato, Chilli, Brinjal, Potato, Onion, Bhendi, Cauliflower, Cabbage, Marigold, chrysanthemum, Aster, Rose, Gladiolus, Coconut, Arecanut, Cashew, Coffee, Betelvine, Banana, Mango, Citrus, Sapota, Guava, Aonla, Aswagandha, Coleus, Sarpagandha, Vinca etc.. Genetic resources and their utilization; Genetics of quantitative and qualitative traits. Breeding for value addition and resistance to abiotic and biotic stresses. Conventional (line breeding, population improvement, hybrids) and other approaches (DH Populations, Marker Assisted Breeding, Development of new male sterility systems), transgenics. National and International accomplishments in genetic improvement of major horticultural crops and their seed production.

References:

Chopra, V.L., 2001, Breeding Field Crops - Theory and Practice. Oxford & IBH.

Khairwal, I.S., Rai, K.N. and Harinaryanan, H. (Eds.). 1999, Pearl Millet Breeding. Oxford & IBH.

Singh, B.D., 2006, Plant Breeding - Principles and Methods. Kalyani.

BCI 612 Marker Development and Gene Mapping (1+1)

Theory : Concepts ofRFLP, RAPD, SSR, AFLP, SCAR, STS, CAPS, EST, SNP and marker development; Study of Gene based markers and candidate genes; Utilization of markers and genes in map construction; Assigning of markers to chromosomes with their distances; Selection of suitable population for

QTL mapping using DNA markers; software for construction of genetic map, MAPMAKER EXP and other software to detect genes and its back-end functions; examining the Output of gene map; Fixing linear order and distances of markers on chromosomes, Interpretation and assigning linkage groups; Use of trisomics, and cytogenetic maps for assigning markers to linkage groups; Generation of data for phenotype and genotypes. Major gene mapping and location of genes to linkage groups; Estimation of crossing over and linkage of markers and genes.

Practical : Different types of mapping populations, steps in map construction; Generation of marker data for linkage analysis; scoring of data and statistical analysis. Fixing of threshold LOD; Maximum likelihood and Kosambi functions; Multipoint linkage analysis for detection of linked markers. Procedure for Development of mapping populations; Usage of QTL-MAPMAKER, Cartographer and other softwares used in gene mapping. Single marker analysis; Interval mapping; Linkage disequilibrium, population structuring and Association mapping;; Interpretation of QTL analysis output, QTL nomenclature; Examples of successful QTL mapping and their uses.

Reference:

P.S. Srivastava, AlkaNarula, SheelaSrivastava Plant Biotechnology and Molecular Markers

N.ManikandaBoopathi Genetic Mapping and Marker Assisted Selection Basics, Practice and Benefits

Griffiths AJF, Miller JH, Suzuki DT, et al. 2000. An Introduction to Genetic Analysis. 7th edition. New York: W. H. Freeman;

Peter S. White and Tara C. Matise Genomic Mapping And Mapping Databases

BCI 613 Advances in Crop Biotechnology (2+1)

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

Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc) 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. Molecular breeding; constructing molecular maps; diversity assessment and phylogenetic analysis; molecular tagging of genes/traits; selected examples on marker-assisted selection for qualitative and quantitative traits.

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.

Practical : Isolation of Bt Strains; Characterization of protein; proteinase inhibitors, bioassay; isolation and characterization of lectins and their bioassay; isolation of chitinases and genes for chitinases from different samples; Bioassay against fungal pathogens, isolation of PR proteins against disease causing organisms, isolation of HSP's and genes, assay to determine the role of HSP's in salinity and temperature stress.

References:

AraKirakosyan, Peter B. Kaufman Recent Advances in Plant Biotechnology

Jameel M. Al-Khayri, Shri Mohan Jain, Dennis V. Johnson Advances in Plant Breeding Strategies: Breeding, Biotechnology and Molecular Tools

R C Dubey Advanced Biotechnology

Jan S. Tkacz, Lene Lange Advances in Fungal Biotechnology for Industry, Agriculture, and Medicine

BCI 614 Commercial Plant Tissue Culture (1+1)

Theory : Micropropagation of commercially important plant species; plant multiplication, hardening and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing.Production of useful compounds via biotransformation and secondary metabolite production; suspension cultures, immobilization, examples of chemical being produced for use in pharmacy, medicine and industry.Value addition by transformation; development, production and release of transgenic plants; patent, biosafety, regulatory, environmental and ethical issues; management and commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/ industries.

Practical : Components of plant tissue media and preparation of MS, B5 and Nitch media; maintenance and selection of explants, sterilization of explants and culturing of explants; induction of callus in carrot, tobacco and other crops; induction of cell suspension cultures in carrot, tobacco and other crops; induction of callogenesis in carrot, tobacco and other crops; induction of rhizogenesis in carrot, tobacco and other crops; invitro propagation of banana- explants selection, preparation and sterilization, media preparation, culture induction, sub culturing, rooting, hardening and ex vitro establishment; measurement of growth in callus cultures, organ cultures and cell suspension cultures.

BCI 615 Advances in Seed Science Research (3+0)

Theory : 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.

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).

Detection and identification of seed borne fungi, bacteria, viruses, nematodes and insect pests through advanced techniques like ELISA, PCR based techniques etc.

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.

References:

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.

Singhal NC. 2003. Hybrid Seed Production in Field Crops. Kalyani.

Thompson JR. 1979. An Introduction to Seed Technology. Leonard Hill.

BCI 616 Commercial Biotechnology (2+0)

Theory : Micropropagation of commercially important plant species; plant multiplication, hardening and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing. 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. Value-addition by transformation; development, production and release of transgenic plants; patent, bio-safety, regulatory, environmental and ethic issues; management and commercialization. Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/industries. Advances in primary metabolism products, production of secondary metabolites, bacterial antibiotics and non ribosomal peptide antibiotics; Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains, Metabolic pathway engineering of microbes. Microbial enzymes and pharmaceuticals.Bioreactors, their design and types, Microencapsulation technologies for immobilization of microbial enzymes.Bioremediation and production of eco-friendly agricultural chemicals, bio-pesticides, bio-herbicides, bio-fertilizers, bio-fuels, etc.

References:

Commercial Plant-Produced Recombinant Protein Products: Case Studies (Biotechnology in Agriculture and Forestry) 2014th Edition

John A. Howard (Editor), Elizabeth E. Hood (Editor) Environmental Biotechnology Commercial Applications

V K Saran Plant Biotechnology

Ricroch, Agnes, Chopra, Surinder, Fleischer, Shelby (Eds.) Experience and Future Prospects

NdukaOkafor Modern Industrial Microbiology and Biotechnology

DevarajanThangadurai, JeyabalanSangeetha Industrial Biotechnology: Sustainable Production and Bioresource Utilization

BCI 617 Seed Processing and Storage (2+1)

Theory : 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 horticultural crops, viability equations and application of nomograph. 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, machines; seed blending. Assembly line of processing and storage, receiving, elevating and conveying equipments, plant design and layout, requirements and economic feasibility of seed processing plant. 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.

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.

BCI 618 Seed Quality Testing (2+1)

Theory : 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. 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. 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 weed seed and other seed by number per kilogram; determination of other distinguishable 60 varieties (ODV); determination of test weight and application of heterogenity test.

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.

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.

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.

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.

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.

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 61 methods, agar method and embryo count methods; testing coated/pelleted seeds.

BCI 619 Seed Storage and Deterioration (1+1)

Theory : 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.

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

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.

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 : Study on the effect of storage environmental factors (RH, SMC and temperature) on seed longevity. Study on 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.

References:

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 SubtropicalRegions. 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.

BCI 620 Testing for Genuineness & Purity of cultivars (1+1)

Theory : 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 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.

DNA finger printing (RAPD, SSR, AFLP etc) and their use in varietal purity testing and registration of new varieties. 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, use of chromatography for analysis of secondary compounds.

References:

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.

Nema NP. 1986. Principles of Seed Certification and Testing. Allied Publs.

BCI 621 DUS Testing for Plant Variety Protection (2+1)

Theory : 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.

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 of common knowledge, reference collection, grouping of varieties, types and categories of characters; technical questionnaire.

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.

BCI 622 Hybrid Seed Production (1+1)

Theory : Introduction, concepts of hybrid seed production; Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in vegetables and other horticultural crop plants for crop improvement. Pre requisites for hybrid seed production; mechanisms and management of pollination in autogamous and allogamous crops; basic principles in hybrid seed production. Techniques of hybrid seed production - emasculation and crossing: use of selfincompatibility, 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. 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; Principles and techniques of hybrid seed production of various crops viz vegetables, flowers , spices and medicinal plants .

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, Band 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.

References:

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

A. MINOR COURSES

AGRICULTURAL ECONOMICS

AEC 604 ADVANCED PRODUCTION ECONOMICS (1+1)

Theory : Agricultural production-Relationship between farm planning and production economics-scope of agricultural production and planning methods/procedures in agro-economic research and planning. Productionfunctions, components, assumptions, properties and their economic interpretation-concepts of homogeneity, homotheticity, APP, MPP, elasticities of substitution and their economic relevance. Production relationsoptimality. Commonly used functional forms, nature, properties, limitations, estimation and interpretation-linear, Spillman, Cobb Douglas, quadratic, multiplicative (Power) functional forms-Translong 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 optimumdetermination of economic optimum with production function analysis, input use behavior. Decision making. Decision making with multiple inputs and outputs-Decision making with no risk-cost of wrong decisions. Cost curves. Duality of profit and cost functions-principles and derivation of demand and supply functions. 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. Risk and uncertainty in agriculture incorporation of risk and uncertainty in decision-making-risk and uncertainly and input use level-risk programming. Economic analysis of risk mitigating measures, economics of Intergraded farming system.

Practical : Estimation of different forms of production-Optimal input and product choice from estimated functions-Derivation of demand and supply functions-Estimation of cost functions and interpretations-Estimation of factor shares from empirical functions estimated-Estimating production functions incorporation of technology-Estimation of efficiency measures-Stochastic, probabilistic and deterministic frontier production functions-Simulation models for agricultural production decisions.

Suggested References

Gardner B L and Rausser G C 2001. Hand Book of Agricultural Economics. Vol. I A Agricultural Production. Elsevier.

Palanisami K P, Paramashivam and Ranganathan C R 2002, Agricultural Production Economics: Analytical Methods & Applications Associated Publishing Co.

Heady E O, Economics of Agricultural Production and Resource use. Prentice hall.

S.S. Johl & J.R. Kapoor, Fundamentals of farm Business Management.

V.T. Raju & D.V.S. Rao, Economics of Farm Production and Management.

Damodar N. Gujarati, and Dawn C. Porter, Basic Econometrics 5th Edition.

AEC 608 OPERATIONS RESEARCH (0+1)

Practical : Introduction and nature of operations research. History of operations research, characteristics of operations research. Stages in development of operations research, project-formulation and components of a problem. Deterministic models, Linear programming and its applications. Transportation models, Dynamic programming. Constrained and unconstrained non-linear programming methods, multiple objective decision making. Stochastic models, Markov chains, Bayesian analysis. Theory of inventory management: Economic ordering quantity and relate4d issues, maintenance and replacement problems Network flow problems. PERT and critical path methods. Queuing theory. Game theory-business games, Monte Carlo method, Simulations, Heuristic programming Application of OR techniques to agriculture. Numerical examples and case studies in the following OR problems. Formulation of OR problems and solving them using various steps. Application of linear programming and dynamic programming, Inventory problems, networks flow problems, PERT and critical path methods, queuing problems, stochastic and Markov chains, unconstrained and constrained non-linear programming models. Application of operations research to specific agricultural problems.

Suggested References

Gardner B L and Rausser G C 2001. Hand Book of Agricultural Economics. Vol. I A Agricultural Production. Elsevier.

Palanisami K P, Paramashivam and Ranganathan C R 2002, Agricultural Production Economics: Analytical Methods & Applications Associated Publishing Co.

Heady E O, Economics of Agricultural Production and Resource use. Prentice hall.

S.S. Johl & J.R. Kapoor, Fundamentals of farm Business Management.

V.T. Raju & D.V.S. Rao, Economics of Farm Production and Management.

Damodar N. Gujarati, and Dawn C. Porter, Basic Econometrics 5th Edition.

AGRICULTURAL EXTENSION

AEX 603 ADVANCES IN TRAINING TECHNOLOGY (1+1)

Theory : 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. Designing an effective training session-the semantics involved, Designing experiential training sessions, simumation exercises, and openness in training transaction-managing delimmas, ambivalence and conflicts and confusion (for both trainers and trainees). 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. Participatory Training Techniques-Lecutre, Brainstorming, Group discussion and Training Games. Role Play, Psychodrame, Coaching, Counseling, etc., Trainer's roles and dilemmas, Factors Affecting Training Effecitveness 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.

Regerence
FAO Publication, 2007., Horticultural Marketing –A Resource and Training Manual for Extension Officers –FAO,
C. Karthikeyan Etal, A Text Book of Agricultural Extension Management

AEX 604 ORGANIZATIONAL DEVELOPMENT (1+1)

Theory : Introduction to organizations: Concept and characteristics of organizations, Organizational Behaviour-Context and concept-levels of organizations-formal and informal organizations, Theories of organizations: Nature of organizational theory-classical theories-features of Bureaucracyadministrative theory and Scientific management-Neo-classical theories-the human relations movement-modem theory. Systems approach to study organization needs and motives-Attitude, values and ethical behaviouralienation 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. 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. 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 affecting 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.

Reference:
Singh Ashok K., Extension strategies for Agriculture and Rural Development

Dr. T. Radhakrishnan, Dr. M. Iseael Thomas, Dr. L. Nirmal., 2009., Advance and Challenges in Agricultural Extension and Rural Development
A.K. Singh, 2012., Agricultural Extension Impact and Assessment
B.S. Hansra and K. Vijayaraghavan ., 2003., Agri Business and Extension Management
A. Tripathi., A Text Book of Research Methodolgy in Social Sciences

AEX 608 MEDIA MANAGEMENT (1+1)

Theory : Media Management-Introduction, Definition, Principles and Significance of Management. Media Ownership patterns in India.-Proprietorship, Partnership, Private Ltd, Public companies, Trusts, Cooperatives, Religious Institutions (Societies) & Franchisees (Chains). Marketing Function-Product, Price, and Placement & Promotions. 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 ofthe 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. 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 Broadcasting, Broadcasting Policy and code. Community Radio-Concept, meaning, role in TOT, Cases of Community radio. Television-History-Role in TOT, Fundamentals of Te1evision 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. Advances in communication Technology-Management of Agricultural Information System (MArS). 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 and importance.

Practical : Writing for Print Media-Writing News / Success Stories / Feature articles for different topics related to Agriculture & allied fields. Exercise of editing & proofreading 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.Y. 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.

Reference

Heather, N., FAO Publication., 2007., Communication in Extension A Teaching and Learning Guide FAO

Dubey, S.K. Sah, Uma, Singh A.K., 2011., Linkage Perspective in Agricultural Extension

Shruti ., 2015., Instant Extension Education (for JRF)

Dr. G. Pankajam., 2000., Extension Third Dimension of Education

Lahiri B., Mukhopadhyaya, Adhikari M.M., 2012., Mass media in Agricultural Extension

AGRICULTURAL MICROBIOLOGY

AMB 601 ADVANCES IN FERMENTATION TECHNOLOGY (1+1)

Theory : 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-online measurement systems, computer application. Media for microbial fermentation; Criteria in media formulation. An overview of downstream processing. New strategies for isolation of industrially important microbes and their genetic manipulations; Microbial production of health care products. Antibiotic fermentation research; steroid transformation. Recent developments on production of primary and secondary metabolites,

Treatment of biological wastes, microbial inoculants and enzymes for waste treatment. 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, F ermeptation by improved strains of yeast for production of alcohol and beer, Microbial production of important antibiotocs, enzymes and organic acids, Bioremediation of industrial effluents.

Suggested References

Peter F. Stanbury, Allan Whitaker and Stephen J Hall Principles of Fermentation Technology

D. Perlman Microbial Technology

Carlos Ricardo Soccol, Ashok Pandey, Christian Larroche., 2013 Fermentation Processes Engineering in the Food Industry

Brian McNeil, Linda M. Harvey, 2008, Practical Fermentation Technology

Antonio Mendez-Vilas, 2014 Industrial, medical and environmental applications of Microorganisms

Goldberg E, 1996, Handbook of Downstream processing

Verrall, 2013, Downstream Processing of natural products a practical Handbook

B. Sivasankar, Bioseparations: Principles and Techniques [print replica]Kindle Edition

Henry C Vogel, Celeste M Todaro Fermentation and biochemical Engineering Handbook Principles process Design and Equipment

Microbial inoculants and Biofertilizer Technology Saujanya books

Christopher Boulton, David Quain Brewing yeast and fermentation

AMB 604 CURRENT TOPICS IN SOIL MICROBIOLOGY (1+1)

Theory : Molecular ecology and biodiversity of soil microorganisms; Survival and dispersal of microorganisms. Microbial successions and transformation of organic matter; Role of microorganisms in soil fertility. Bioremediation of polluted soils; Biological control of Soil bOI11e Plant Pathogens. Other topics of current interest.

Practical : Activities of soil enzymes; Study of chemoautotrophic bacteria, Heterotrophic nitrification; Microbial transformation ofxenobiotics. Study of microbial successions.

Suggested References

Koltai, Hinanit, Kapulnik, Yoram , Arbuscular mycorrhizas: Physiology and function

Mukerji K.G. Manoharachary, C. Chamola B P., Techniques in Mycorrhizal Studies

Declerck, Stephane, Strullu, Desire-Georges, Fortin, Andre., In vitro culture of mycorrhizas

Tancredo Souza., Handbook of Arbuscular mycorrhizal fungi 1st ed. 2015, kindle Edition

AMB BIOLOGY AND PRODUCTION OF MYCORRHIZA (2+1)

Theory : Type of mycorrhizae-ecto, vesicular-arbuscular, Ericoid and orchidaceous mycorrhizae, their occurrence, distribution and significance in natural ecosystem. Ectomycorrhizae-fungi involved, their morphology ecology and physiology. Methods of inoculation-plant response to inoculation-mechanism of improved plant growth. Production of the VA mycorrhizae inoculum and its application. Vesicular-arbuscular mycorrhizae taxonomy of the fungi, morphology and histology, quantification in plnat roots and in soil. Isolation, axenic and pot culture. Procedures for inoculation, plant response to colonization. Physology and ecology of the symbiosis. Biological interactions with other soil flora and fauna. Mass multiplication techniques. Exploitation of mycorrhizae in agriculture, horticulture and forestry.

Practicals : Quantification of mycorrhizae in plant roots: methods for the recovery of mycorrhizal propegules from soil: spore germination and axenic culture of endomycorrhizae; production of endomycorrhizal inoculum; evaluation of plant responses to mycorrhizal inoculation Study tour to collect samples for isolation and identification of mycorrhizal fungi.

References

The mycorrhizae Diversity, Ecology and Applications 2008, M. Tiwari & S.C. Sati (Auditors), Daya Publishing House Delhi. Fundamentals of Mycorrhizal biology and Biotechnology 2002, Ramarao Pannuri, Agrotech Publishing Academy, Udaipur

AGRONOMY

AGR 601 CURRENT TRENDS IN AGRONOMY (3+0)

Theory : Agro-physiological basis of variation in yield, recent advances in soil-plant-water relationship. Globalization of agriculture and WTO, precision agriculture, contract farming, organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures. Crop residue management in multiple cropping systems; latest developments in plant management, weed management, cropping systems, grassland management, agro-forestry, allelopathy. GIS, GPS and remote sensing for crop management, global warming, GM crops, seed production technology; seed certification, seed multiplication, hybrid seed production etc. Concepts of system agriculture; holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy.

References

Gordan, G. 1992. System Simulation. 2nd Ed. Prentice Hall. Delhi.

Govardhan, V. 2000. Remote Sensing and Water Management in Command Areas: Agroecological Prospectives. IBDC.

NAAS, 2009. State of Indian Agriculture. National Academy of Agricultural Sciences, New Delhi.

Narasaiah, M.L. 2004. World Trade Organization and Agriculture. Sonali Publ.

Negi, S.S. 2008. Biodiversity and its Conservation in India. Indus Publishing Company. Palaniappan, SP. and Annadurai, K. 2006. Organic Farming - Theory and Practice. Scientific Publ. Penning de Vries, F.W.T. and Van Laar, H.H. (Eds.). 1982. Simulation of Plant Growth and Crop Production. Wageningen Centre for Agricultural Publications and Documentation, Netherlands.

Sharma, Premjit. 2007. Contract Farming. Daya Publishing House, New Delhi.

Sharma, A.R. and Behera, U.K. 2010. Resource Conserving Techniques in Crop Production. Scientific Publ.

Gupta, O.P. 1998. Modern Weed Management. AgroBotanica, Bikaner, 488 p.

Gupta, O.P. 2007. Weed Management – Principles and Practices. Agrobios.

Subramanian, S., Ali, A.M. and Kumar, R.J. 1997. All About Weed Control. Kalyani Publ. Walia, U.S. 2003.Weed Management. Kalyani Publishers, Ludhiana.

Rao, S.C and Ryan, J. 2007. Challenges and Strategies of Dryland Agriculture. Scientific Publishers.

Panda, S.C. 2004. Cropping Systems and Farming Systems. Agribios.

Raman, K.V. and Balgur u, T. 1992. Farming Systems Research in India: Strategies for Implementation. Proceedings of the National Workshop, November 25-28, 1991, NAARM, Hyderabad, India

Raman, K.V. and Balgur u, T. 1992. Farming Systems Research in India: Strategies for Implementation. Proceedings of the National Workshop, November 25-28, 1991, NAARM, Hyderabad, India

Singh, Pratap and Maliwal, P.L. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ.

Michael, A.M. 1978. Irrigation: Theory and Practice. Vikas Publ.

FAO. 2002. Organic Agriculture, Environment and Food Security. FAO Publ.

Veeresh, G.K., Shivashankar, K. and Suiglachar, M.A. 1997. Organic Farming and Sustainable Agriculture. Association for Promotion of Organic Farming, Bangalore. WHO. 1990. Public Health Impact of Pesticides Used in Agriculture. WHO Publ.

AGR 602 CROP ECOLOGY (2+0)

Theory : Concept of crop ecology, agricultural systems, ecology of cropping systems, principles of plant distribution and adaptation, crop and world food supply Agro-ecological regions and agro-climatic zones of India and Karnataka. Ecosystem characteristics, types and functions, terrestrial ecology, flow of energy in ecosystem, ecosystem productivity, biomass, succession and climax concept. Ecological factors affecting crop production. 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. Exploitation of solar energy in crops; vertical distribution of temperature; efficiency in crop production. 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.

References

Chadha, K.L. and Swaminathan, M.S. 2006. Environment and Agriculture. Malhotra Publ. House. Critchfield, H.J. 1995. General Climatology. Prentice Hall of India.

Hemantarajan, A. 2007. Environmental Physiology. Scientific Publ. Kumar, H.D. 1992. Modern Concepts of Ecology. 7th Ed. Vikas.Publ. Lal, D.S. 1998. Climatology. Sharda Pustak Bhawan.

Lenka, D. 1998. Climate, Weather and Crops in India. Kalyani Publ. Menon, P.A.1991. Our Weather. National Book Trust Publ.

Sahu, D.D. Agrometeorology and Remote Sensing: Principles and Practices.

Sharma, P.D. 1998. Ecology and Environment. Rastogi Publ.

Varshneya, M.C. and Balakrishana Pillai, P. 2003. Textbook of Agricultural Meteorology. ICAR Publ.

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

AGR 604 ADVANCES IN CROP GROWTH AND PRODUCTIVITY (2+1)

Theory : 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; differences in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation. 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 rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages. 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. Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype 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, aggressivity, competition index etc in intercropping. Senescence' and abscission indices, Analysis of productivity trend in rainfed areas, Analysis of productivity trend in irrigated areas

Donald, L. Smith and Chantal, Hamel (Eds). 2002. Crop Yields –Physiological Processes. Springer.- Verlag, Berlin Edward, Arnold, John, H., Thornley, M. and Johnson, I.R. 1997. Plant and Crop Modeling: A Mathematical Approach to Plant and Crop Physiology. Blackburn Press.
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Hay, R.K.M. and Porter, J.R. 2006. The Physiology of Crop Yield. Blackwell Publisher.
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Jone, A., Baligar F., 1991 Growth and Microal Horticultural field crops Marcel Decker publisher PP 488
Sottari A and Sinclair T R 2012 Modeling physiology of crop development growth and yield CABI Hoswardy PP 368
Fageria H K, Baligar V C., and Clark R B., 2016 Physiology of crop production CRC press PP 356.

AGR 607 INTEGRATED FARMING SYSTEMS (2+0)

Theory : Farming systems; definition and importance; classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply; enterprises in farming systems. Concept of sustainability in farming systems; efficient farming systems; natural resources-identification and management. Farming system approach, concept of integration-Production potential of different components of farming systems; interaction and mechanism of different production factors; stability in different systems; eco-physiological approaches to farming systems. Simulation models for farming systems; nutrient recycling in farming systems-sustainability, input rationalisation; preparation of different farming systems models; New concepts and approaches of farming systems and cropping system. Farming system approach for sustainability; Energy concept in farming systems-evaluation based on energy relations. Case studies of different farming systems

Reference:

Behera, U.K., Das, T.K. and Sharma A.R. 2009. Manual on Multicriteria Decision Making and Optimization Methodology for Sustainable Farming. Division of Agronomy, IARI, New Delhi.
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Malcolm, Hall. 2001. Farming Systems and Poverty: Improving Farmers Livelihood in Changing World. FAO and World Bank, Rome and Washington, D.C.

Palaniappan, S.P. and Sivaraman, K. 1996. Cropping Systems in the Tropics: Principles and Management. New Age Publ.

Panda, S.C. 2004. Cropping Systems and Farming Systems. Agribios.

Raman, K.V. and Balgur u, T. 1992. Farming Systems Research in India: Strategies for Implementation. Proceedings of the National Workshop, November 25-28, 1991, NAARM, Hyderabad, India

Rangaswamy, A., Annadurai, K., Subbain, P. and Jayanti, C. 2002. Farming Systems in the Tropics, Kalyani Publishers.

Sankaran, S. and Mudaliar, T.V.S. 1997. Principles of Agronomy. The Bangalore Printing & Publ. Co.

Singh, A.K., Sharma, S.K., Batra, P.K. and Sharma, N.K. 2003. Instruction Manual for On-farm Research (Cropping Systems). Project Directorate for Cropping Systems Research, Modipuram, Meerut.

CROP PHYSIOLOGY

CPH 601 FUNCTIONAL GENOMICS AND GENES ASSOCIATED WITH A FEW PHYSIOLOGICAL PROCESSES (2+0)

Theory : 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. Genetic tools for plant development Understanding the importance of mutants in unravelling 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- Troughput TAIL-PCR as a tool to identify DNA flanking insertions, injuries and resistance in plants, practical ways to overcome the effect of low temperature stress through soil and crop manipulations. High temperature or heat stess: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations. Water deficit stress: meaning of plant water deficit injury and resistance, practical ways to overcome the effect of water deficit stress through soil and crop manipulations. 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. 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. water deficit stress:

meaning of plant water deficit injury and resistance, practical ways to overcome the effect of water deficit stress through soil and crop manipulations. Excess water or flooding stress: meaning of excess water stress, its kinds and effects crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations. 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. Other stresses Hailstorms and its effect on crop growth, ways to overcome the stress. Mechanical impedance of soil and its impact on plant growth; measures to overcome soil mechanical impedance. 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 seedlinggrowth, Measurement of low temperature injury under field conditions. High-Throughput Tilling for functional genomics. Gene knock out approaches: Antisense technology, Virus Induced Gene Silencing (VIGS), Custom Knock-outs with Hair-pin RNA-mediated gene silencing and other Silencing tools, Complementation studies, DNA micro arrays. Gene over expression as a tool to elucidate gene function: Transient expression, Transgenics. Proteomics: Networking of Biotechnology for interpreting gene functions. Yeast two hybrid systems to study proteinprotein interaction to study gene functions, Proteomics as a functional genomics tool, Crystallographic and NMR approaches to determine protein structures. Functional characterization of genes associated with important cellular processes influencing crop growth and development. Case studies of genes controlling photosynthesis, respiration, photorespiration, fatty acid biosynthesis, nutrient uptake, flowering, seed protein quality and quantity.

References

The handbook of plant functional genomics by Gunter katl and kahid meksem published by wily Blackeves

Bioinformatics and functional genomics. by J.Pevnsen

Functional genomics methods. by Brownstein:ISBN9788181287618:

Buchanan, B., Gruissem, W and Jones R., by Biochemistry and molecular biology of plants

CPH 602 SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES (2+0)

Theory : General aspects: Introduction to signalling-Long range (diffusible) signalling and short range (contact) signalling. Components of signalling- Upstream components: receptor and ligands concept-types of ligand and its relevance- receptor kinases-Two component sensing system. Down stream components: G. proteins-second messengers-cyclic AMP, adenylate cyclise cascade, cyclic GMP, calcium-calmodulin-kinases-Effector molecules (transcription factor). Hormone signalling: Hormone binding receptors- Transduction process. Effector molecules and gene expression. Specific signalling pathways of Auxins, Cytokinin, Gibberellins, Ethylene, ABA, Brassinosteroids which leads to formative effects. Tha cross talk in the signalling of different hormones-significance of studies with hormone action mutants. Light signalling: Perception of light-pigments involved-activation of phytochrome/ cryptochrome (study of mutants). Light signal transduction-Multiple signalling cascades-identification of signalling components through mutant analysis-changes in gene expression. Abiotic stress signalling: Sensing of environmental factors (Temperature- Osmoticum-Ionic stress) activation of specific molecules and secondary messangers-Activation of Down stream components-leading to stress gene expression. Case studies with different abiotic stresses. Cross talk between signalling pathways. Signal perception and transduction in plant defence responses: Role of salicylic acid and active oxygen species. Signaling cascade during leaf senescence, abscission, flowering and tuberisation. Transcription factor as signaling regulatory tools for improving growth processes case studies: Tbi-lateral branch development, Shi 4-grain shattering, GA1-Dwafing. MADS, KNOX-flowering development, HAT 4-Shade development, AP2- EREBP-biotic stresses.

Reference

Plant hormone: Biosynthesis signal transduction and action by Davis P.J
Plant Cell monographs plant growth signaling by Las210 Bogre and gerrit Beemster
Physiology and molecular Biology in plant. by K.V.Madhav Rao :Springer
Photomorphogenesis in plant: Functions and signal transduction. by Eberhart Schater :publish - Springer
Resistance response physiology and signal transduction.By Dierk scheel
Introduction to plant physiology by William G Hopkins Norman P.A.
Huner
Signal transduction in plant growth and development Ed. By D.P.S. Verma

CPH 603 MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS (2+1)

Theory : 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. The advantages of "Trait based" breeding approaches. Concept of molecular markers, various types of dominant and co-dominant marker systems. Relevance and development of mapping populatios and genetic analysis using marker systems. Advantages of association mapping and the concept of linkage, LD decay and population structure. Statistical analysis to assess the variance in phenotypic traits and molecular data. Assessment of genetic parameters such as heritability, genetic advance etc. Strategies for QTL introgression and Marker Assisted Selection (MAS). Map based cloning of novel genes and alleles. Allele mining. Transgenic approach in improving physiological processes-Introduction to G MOs and a pplication i n crop improvement; gene mining, sequence structure & function of candidate genes for various physiological process associated with specific traits (such as stress tolerance) and their potential benefits in transgenic crops. Cloning full-length candidate genes, stress inducible promoters, strategies to clone and characterize and make conatructs for specific crops, gene stacking strategies, tissue specific expression and functional validation of genes. Transformation of crop plants-Agrobacterium and use of other organisms for transformation-particle gun transformation and other methods. 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. Evaluation of trangenics 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. Issues related to Biosaftey and Registration of Trangenic 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. Fulllength gene cloning, vector construction with specific promoter, gene stacking & transient assaya. Transformation in model system, Crop transformation-agrobacterium mediated transformation (inplanta & invitro), particle gun transformation, Evaluation of transgenics-semi quantitative RTPCR, southern blot, northern blot, western blot and ELISA, biochemical/ physiological assay based on the function of gene & testing LOD.

Reference:

Physiology and Molecular Biology of stress tolerance in plants by Madhav Rao K.V., Raghavendra, A.S and Janardhan Reddy.K.

CPH 604 ADVANCED TECHNIQUES IN PLANT PHYSIOLOGY (0+2)

Practical : Recent experimental techniques to study various physiological processes, Photosynthetic gas exchange measurements, light and CO_2 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 isotopes to understand physiological processes. Radio active isotopes in plant biology. Tools and techniques (molecular and biochemical) to study physiological processes and to screen & assess stress responses in plants, such as (a) DNA & RNAisolation, cDNA synthesis & library construction, semiquantitative & quantitative RT-PCR, northern blot, immunoassays; (b) techniques for defined physiological processes. Methods to phenotype germplasm for specific physiological traits. Quantification of mineral nutrients using advanced instruments like AAS& ICP. Techniques in plant transformation & analysis of transgenic plants. Molecular markers-genetic distance and mapping population concept of linkage maps and identification of QTLS. Instrumentation: Acquaintance of the operation of specific instruments important in physiological research like Mass spec., phosphor-imager, DNA sequencer, spectro-fluorometer, oxygen electrode, etc.

Referenc

Advances in molecular breeding towards draught and self tolerant crops by Ammar E L Akhdar

Plant Pysiology and development . by L.Taiz E Zaiger
Plant Pysiology. By Salisborry and Ross
Plant physiology and Development by Lincoln Taiz, edurdo zeiger Ian M Moller and Angus Murphy (Sixth Edition)
Plant Physiology by Salisbury F B and Ross C W

CPH 605 CLIMATE CHANGE AND CROP GROWTH (2+0)

Theory : History and evidences of climate change and its implications. Effect of climate change on monsoons, hydrological cycle and water availability. 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. Long-term and short-term projections of climate change effects on natural vegetations and ecosystems, crop-pest interaction, area shift, food production and supply. Approaches to mitigate climate change through studies on plant responses. Direct and indirect effects of climate change on plant processes phenology, net carbon assimilation, water relations, grain development and carbon assimilation, water relations, grain development and quality, nutrient acquisition and yield. Conventional and biotechnological approaches to improve the crop adaption to climate change. Relevance of "Genome wide mutants" to identify genes/processes for improved adaption to changing environments. International conventions and global initiatives on carbon sequestration, carbon trading.

Reference

Global climate change and Agriculture. by Fakhri A Bazzaz
Climate change effects on plant growth ,crop yield and livestock. by R.rotter S E: Springer
Eco physiology of Tropical crops by Advim, T and T.T. Ko210WSK (eds)
Plant growth and climate change etd. By James I.L Morison and Michael D. Morecroft
Climate change impacts on plant Biomass growth by Ali Mohammad

CPH 610 MOLECULAR PHYSIOLOGY OF MINERAL NUTRIENT ACQUISITION, TRANSPORT AND UTILIZATION (1+1)

Theory : Overview of essential mineral elements, kinetics of nutrients uptake by plants. Biological and chemical reactions influencing nutrient availability near the root system. Nutrient uptake by root cells, long distance transport from vegetative to reproductive organs during reproductive stage of growth and maturity. Molecular mechanism of nitrate, phosphate, potassium and other nutrients. Multiple transporters for a single ion and their functional regulation. Molecular physiology of micronutrient acquisition. Examples

of genes encoding mineral ion transporter s. Strategies plants adopt to acquire and transport minerals under deficient levels. Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, examples of phosphorous, iron and zinc efficient crop varieties. Breeding crop varieties for improved nutrient efficiency. Plant responses to mineral toxicity.

Practicals : Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels. Quantification of pigment levels, enzyme activities and macro molecules. Recent techniques and instruments for determining nutrient levels in plants. Screening techniques for evaluationof nutrient efficiency. Molecular techniques-expression of specific transcripts under nutrient deficient or sufficient conditions.

Reference

Diagnosis of mineral disorders in plants by Alan Scaife and Mary Fanna

Plant nutritional manual by Benton Jones, J

Plant growth interactions with nutrition and environment by Porter, J.R and Lawlor D W

Principles of plant nutrition by Mengel K and Kirkby E A

FOOD SCIENCE AND NUTRITION

FSN 601 ADVANCES IN CARBOHYDRATES, PROTEINS AND LIPIDS (1+1)

Theory : Carbohydrates, proteins and lipids-their digestion, absorption, metabolism. Inborn errors of metabolism. Metabolic disorders-diabetes, dental caries, obesity, antherosclerosis, hyperlipidemia amd hypertension. Glucose homeostasis determined by insulin/ glycogen ratio; carbohydrates free diet and its metabolic consequences; glycemic index; dietary fiber-its definition, composition, classification, functions and role in various physiological disorders. Classification of protein, new discoveries in prtein and their functions such as protein in Immune system, as lubricants, biological buffers and carriers, evaluation of protein quality: in vitro and in vivo methods, animal and human bioassays: amino acid pool, protein turnover in man with special reference to body size, age and various nutrition and pathogical conditions, regulation of proteins, requirements: novel food source of protein. Effect of insulin, corticosteroids, thyroids, androgen and growth hormone on protein metabolism, inheritable disorders of amino acid metabolism of protein; effect of dietary protein on cardiovascular disease and cholesterol metabolism, adaptation of body to low intake of energy and protein. Estimation of body fat; lipoproteins and hyper lipoproteinemia; hypolipidemic action of PUFA omega-3 fatty acids and oxidation products of cholesterol. Disturbance in lipid metabolism; role of a diet in cardiovascular disorders; high blood cholesterol-causes,

prevention and treatment; hypolipidemic action of rice bran, oat, barley and legumes.

Practical : Assessment of protein quality; project work related to metabolic disorders of proximate principles; blood analysis in relation to NCD (Non Communicable Diseases) and estimation of amylase and protease inhibitors in foods.

Reference

Martin Eastwood and E, K, Edinburgh, 2003, Principles of Human Nutrition, Atlantic Publishers and Distributors Pvt. Ltd. New Delhi.

Ashok Kumar Sharma, 2011, Biochemistry of Nutrition, Random Publications, New delhi.

Mahtab S Bamji, Kamala Krishna Swamy, GNV Brahmam, 2016, Text Book of Human Nutrition, Oxford and IBH Publishing Company, Pvt. Ltd., New delhi.

Terene Forro, 2013, Recent Advances in Nutritional Biochemistry and Metabolism, Random Publications Pvt. Ltd. New Delhi.

Sharma D. C. and Sharma D., 2015, Nutritional Biochemistry, CBS Publishers and Distributors Pvt. Ltd, New Delhi.

Gajalakshmi R., 2012, Nutrition Science, CBS Publishers and Distributors Pvt. Ltd, New delhi.

Sunetra Roday, 2012, Food Science and Nutrition, Oxford University Press, New delhi.

Srilakshmi, B., 2003, Food Science, 3rd Edition, New Age International Publishers, New Delhi.

Sadashivam S and Manickam, A., 2008, Biochemical Methods, New Age International Publishers, New Delhi.

Srilakshmi, B., 2005, Dietetics, 5th Edition, New Age International Publishers, New Delhi.

Ranganna, S, 2001, Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Tata- McGraw Hill, New Delhi.

FSN 604 ADVANCES IN FOOD SCIENCE AND TECHNOLOGY (1+1)

Theory : Recent advances in the field of carbohydrates, lipids, proteins, vitamins and minerals in relation to human nutrition. Nutrogenomics, incorporating genetics into dietary guidance. Recent advances in the field of food analysis and food fortification. Foods of future; special nutrients. Foodprocessing and product development; regulating food processing and preservation through TQM and HACCP. GM foods and their health implications; functional foods and organic foods, impact of WTO in food regulation.

Practical : Product development and shelf life of nutritionally fortified foods using advanced technologies, field study of food processing and preservation in relation to TQM and HACCP in industry.

Reference

Mudambi and Sumati R., 2006, Food Science, New Age International Publishers, New Delhi.

Vikash P, M., sabu Thomas, Laura B, Ituriaga, Pablo Daniel Ribotta, 2013, Advances in Food Science and Technology, Scrivener Publishing LLC, New Delhi.

Suri S and Malhotra, A., 2013, Food Science, Nutrition and Safety, 2013, Pearson Education Pvt. Ltd, New Delhi.

Ranganna, S, 2001, Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Tata- McGraw Hill, New delhi.

Krammer A And Twigg B, A., 1973, Quality Control in Food Industry, AVI Publishers Pvt. Ltd., New delhi.

Srilakshmi, B., 2003, Food Science, 3rd Edition, New Age International Publishers, New Delhi.

Meyer, L.H. 1991, Food Chemistry, Affiliated East-West Press Pvt.Ltd., New Delhi.

Swaminathan, M. 1995, Food Science and Experimental Foods, Ganesh and Co., Madras.

Potter, N. 1987, Food Science, CBS Publishers and Distributors, Delhi.

GENETICS AND PLANT BREEDING

GPB 601 Marker Assisted selection in Crop Improvement (1+1)

Theory: Association of markers with genes; Genetics of DNA markers; principles of Marker Assisted Selection; Co-segregation and crossing over; Limitation and advantages of Marker Assisted Selection; Role of DNA markers for transfer of major genes and QTL, Role of Markers in backcross breeding and in Pedigree breeding; Major gene-pyramiding using DNA markers; Advantages and limitation of gene pyramiding, DNA marker based detection of genes and QTLs in pyramided plants; Phenotypic evaluation of gene pyramids and detection of gene effects; QTL pyramiding, intricacies and advantages. Development of variety-trait-specific markers and assigning of finger prints; Use of DNA markers in other breeding methods-in mutants, polybloids and transgenics etc; Introduction to Genomics, bioinformatics. Markers Vs Conventional selection; priorities and cost effectiveness; Application of MAS techniques in screening genetically diverse plant species; Examples of successful marker assisted selection in crop plants.

Practical: Working out examples of Marker Assisted Selection in Rice and

other crops; Estimating the Genetics of traits using DNA –phenotypes combination; Examples of Co-segregation and linkage using markers; Calculating Genetic distances of gene and markers with tagged genes; Estimating the accuracy of marker assisted selection V s conventional Selection; identifying suitable traits for MAS; Analysis of QTL data and identifying suitable markers for qU4l. ntitative traits; Interpreting results. Analysing examples of markers and conventional selection. Discussions on usefulness of markers of successful MAS. Prioritizing the selective use of markers for selection in plant breeding.

GPB 609 LABORATORY TECHNIQUES IN PLANT MOLECULAR BREEDING (0+1)

Practical: Laboratory equipments needed for plant molecular biology experiments, safety considerations in handing chemicals, and proper disposal of by-products and wastes, Lab etiquette. Laboratory techniques for DNA and RNA extraction, purification, quantification and visualisation. DNA digestion and DNA transfer techniques. RFLP, PCR, RAPDs, Microsatellites, SNPs and genes used in selecting desired traits for rapid selection. Marker assisted back cross breeding for shortening of breeding cycles. DNA fmger printing of important varieties and molecular characterization of plants and pathogens. Reading and documenting results data analysis and interpretation. Using of results and applications.

GPB 614 ADVANCES IN CYTOGENETICS (2+0)

Theory: Principles and procedures of genome analysis, colinearity among genome and synteny, Use of conventional and modern techniques, morphological cytological, genetical, biochemical and molecular tools used in major crops like wheat, rice, maize, sugarcane, brassica, cotton, tobacco, potato; Location and mapping of genes on chromosome by different methods-conventional,. Monosomics, telocentric methods; identification of chromosomes involved; balanced lethal system-its maintenance and utility; Trisomic-types, breeding behavior, balanced tertiary trisomies and their use in hybrid seed production; Gene transfer by distant hybridisation, Alien chromosome addition and substitutions, chromosomal control of meiotic pairing and induced transfer of alien genes.

BIOCHEMISTRY

BCM 601 ADVANCED ENZYMOLOGY (2+0)

Theory: 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. 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 OH of active site amino acids. Kinetics of bisubstrate reactions, mechanism determination by radioisotope exchange, kinetics of mixed inhibitions, substrate and product inhibition. Role of enzymes in regulation of metabolism, allosteric enzymes and their kinetics, enzyme engineering. Bifunctional enzymes, enzyme engineering.

BCM 602 ADVANCED MOLECULAR BIOLOGY (3+0)

Theory : Organization of prokaryotic genome, nuclear and organelle genes, concept of genome mapping, molecular evolution, cell development and differentiation. Prokaryotic and enkaryotic gene regulation, RNA editing, molecular biology of viruses. Methods of gene isolation and transfer in plants and animals, molecular basis of male sterility, Application of genetic engineering in different fields. Site directed mutagenesis, gene targeting and gene therapy, bioethics and biosafety guidelines and IPR in recombinant DNA research.

BCM 604 CURRENT TOPICS IN BIOCHEMISTRY (1+0)

Theory: Advanced topics related to nutrition and metabolism. Advanced topics related to enzymology and industrial biochemistry. Advanced topics related to molecular biochemistry and immunology. Advanced topics related to metabolic engineering and bioprospecting.

BCM 607 ADVANCED TECHNIQUES IN BIOCHEMISTRY (0+2)

Theory: Isolation and purification of protein from microbial/plant! Animal source. Electrophoretic separation of protein. Determination of molecular weight of protein using PAGEl gel filtration method. Experiments on DNA: isolation, agarose gel electrophoresis and restriction analysis of DNA. Isolation of chloroplast and mitochondria by differential centrifugation and their purification by density gradient centrifugation. isolation and purification of enzymes, isozymic analysis and enzyme immobilization.

SEED SCIENCE AND TECHNOLOGY

SST 601 HYBRID SEED PRODUCTION (1+1)

Theory : Introduction, concepts of hybrid seed production; Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in agricultural, horticultural and other crop plants for crop improvement. Pre requisites for hybrid seed production; mechanisms and management of pollination in autogamous and allogamous crops; basic principles in hybrid seed production. 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. 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 rowslblocks 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; visitto seed production plots etc.

Reference

AGRAWAL R. L., 1996, Seed Technology, Oxford and IBH Publicity Company, New Delhi.

ARYA, PREM SINGH. 2003. Vegetable seed Production Principles. Kalyani Publishers. Ludhiana.

BHASKARAN, M., BHARATI, A., VANANGAMUDI, K, NATARAJAN, N., NATESAN, P., JERLIN, R. AND PRABHAKAR, K. 2003. Principles of Seed Production. Kaisher Graphics, Coimbatore.

FAGERIA, M. S., ARYA, P. S. AND CHOUDHARY, A. K. 2031. Vegetable Crops - Breeding and Seed Production. Kalyani Publishers. Ludhiana.

GEETHARANI, P., SWAMINATHAN, V. AND PONNUSWAMI, V., 2007. Seed Technology in Horticultural Crops. NP.H Publications.

GEORGE, R.A.T., 2009, Vegetable Seed Production (3rd edn.). CAB International.

McDONALD, M.D. AND COPELAND, C.O., 1998. Seed Production Principles and Practices. CBS Publishers and Distributions, New Delhi.

Vegetable Seed Production Technology. International Book Distributing Co. Lucknow, U.P.
SINGHAL, N. C. 2002. Hybrid Seed Production. Kalyani Publishers, Ludhiana.
VANANGAMUDI, K., PRABHU, M., KALAIVANI, S., BHASKERAN, M. AND MANONMANI, V., 2010. Vegetable Hybrid Seed Production and Management. Agrobios (India).

SST 602 IN SITU AND EX SITU CONSERVATION OF GERMPLASM (2+1)

Theory : 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. Ex situ conservation: compgnents, plant genetic resources' conservation in gene banks, national gene banks, 'gene depositories, 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 depositories, genetic stability under long term storage condition. In vitro storage, maintanence of in vitro culture under different conditions, in vitro bank maintenance for temporate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/suspension cultures, protoplastand callus cultures, pollen culture, micropropagation techniques, problems prospects of in vitro gene bank. 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 ahead.

Practical : In situ conservation of wild species-ease studies at national and Intemationallevels-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, celVsuspension cultures, pollen cultures, study of cryotank facility and vitrification techniques, visit to NBPGRINBAGRstudy using fruit crops and other horticultural crops.

Reference

Approach to Monitor the Viability of Accessions During Storage in Seed Banks. FAO /IBPGR Pl. Genet. Resources News 41-3-18.

Dadlani, S.A., B.P. Singh and R.V. Singh. 1981. System of national and international exchange of germplasm and methods of recording followed at NBPGR. Sci. Monogr. No. 5, NBPGR, New Delhi. pp. 72-87.

DARE/ICAR Annual report, 2002-2003. Indian Council of Agricultural Research, Department of Agricultural Research and Education Ministry of Agriculture Government of India, New Delhi.

Ellis, R.H. & Roberts, E.H. & White Head, J., 1980. A New More Economic and Accurate

Frankel, O.H. & Hawkes, J.G., 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press, Cambridge.

Hari Har Ram and Rakesh Yadav, 2007. Genetic Resources and Seed Enterprises Management and Policies, Part-I. New India Publishing Agency, Pitam Pura, New Delhi.(Text book)

J.M.M. Engels, R.K. Arora and L. Guarino. An introduction to plant germplasm exploration and collecting: planning, methods and procedures, follow-up.

Keith G. Briggs. Plant Genetic Resources. Management of Agricultural, Forestry and Fisheries Enterprises-Vol.1.

Operation Manual for National Clonal Germplasm Repository Processed Report. USDAARS and Orgon State Univ. Oregon, USA.

Paroda, R.S. and Arora, R.K., 1991. Plant Genetic Resources Conservation and Management Concepts and Approaches. International Board for Plant Genetic Resources Regional Office for South and Southeast Asia, New Delhi. (Text book)

Ramanatha Rao V. & Toby Hodgkin, 2002. Genetic diversity and conservation and utilization of plant genetic resources. Plant Cell, Tissue and Organ Culture 68: 1–19.

Simmonds, N.W., 1979. Principles of Crop Improvement Longman. Westwood MN. 1986.

Withers, L.A., 1980. Tissue Culture Storage for Genetic Conservation. IBPGR Tech. Rep. IBPGR, Rome, Italy.

SST 604 TESTING FOR GENUINENESS & PURITY OF CULTIVARS (1+1)

Theory : Objective of cultivar purity test, general principles and methods involved. Use and limitations oflaboratory, green house and field plot methods in determination of genuineness of cultivars; a case study in hybrid cotton, reporting of results and inference. 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. DNA finger printing (RAPD, SSR, AFLP etc) and their use in varietal purity testing and registration of new

varieties. Use of computer-based ml;Ichine vision (MVT) for varietal identification and purity testing etc.

Practical : Chemical and biochemical tests for species and cultivar purity testing: phenol test, seed and seedling tests, electrophoretic analysis of seed protein and isozymes, DNA fingerprinting using PCR techniques, use of chromatography for analysis of secondary compounds.

Reference

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.

KHARE, D. AND BHALE, M.S. 2007. Seed Technology. Scientific Publishers (India).

NABINANANDA GHOSH, 2012. Practical Handbook on Seed Quality Testing Technology. Kalyani Publishers, New Delhi.

UMARANI, R., JERLIN, R., NATARAJAN, N., MASILAMANI, P. AND PONNUSWAMY, A.S., 2008. Experimental Seed Science and Technology. Agrobios (India).

SST 605 SEED STORAGE AND DETERIORATION (2+1)

Theory : 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. Factors affecting seed storability-biotic and abiotic and pre-and postharvest 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. Concept of seed ageing and deterioration, its causes, symptoms, mechanisms andrelated theories; different changes associated with the loss ofvigour 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. 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 (RR, 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.

Reference

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.

CBS. Justice OL & Bass LN. 1978. Principles and Practices of Seed Storage. Castle House Publ.

Desai BB. 2007. Seed Handbook: Biology, Production, Processing and Storage. Marcel Dekker.

Doijode SD. 2001. Seed Storage of Horticultural Crops.

KHARE, D. P. 1994. Stored Grain Pests and their Management. Kalyani Publishers. Ludhiana.

Kigel J & Galili G. (Eds.). Seed Development and Germination. Marcel Dekker.

McDONALD, M.D. AND COPELAND, C.O., 1998. Seed Production Principles and Practices. CBS Publishers and Distributions, New Delhi.

VANANGAMUDI, K. VANANGAMUDI, M., NATARAJAN, K., NATARAJAN, N., RAJA, K., SARVANAN, T. AND DJANAGUIRAMAN, M., 2006. Seed Physiology. Associated Publishing Company, New Delhi.

SST 606 ADVANCES IN SEED TREATMENT (1+1)

Theory : Importance and history of seed treatment-definitions, concepts, classification and methods of seed treatment; Use of different seed treatment materials, seed coating and pelleting, seed colorings, polymer coatings, pesticides and other plant products, bio-inoculants, antibiotics and growth regulators; Physical treatments with abrasives, hot and cold temperature, radio frequency waves, magnetic waves, Micro waves, UV-rays, X-rays and gamma-rays; methods of application and their effects on seed quality-seed germination, seedling vigour, storage, seed health etc; Presowing and pre-storage seed treatments-seed priming / invigouration, seed hardening, osmo-conditioning for drought and other

abiotic stress conditions, mid-storage corrections etc. Bio efficacy qf seed treatments, seed quarantine regulations; legal terminologies and labeling requirements, biosafety measures etc.

Practical : Use of inert, chemical and non toxic materials of plant origin; seed coating and pelleting and its influence on seed quality; physical, chemical and energy treatments and their influence on seed quality; use ofbiofertilizers, bio-inoculants and bio-pesticides, plant products on germination and viability; use of organic solvents for infusing bio-active chemicals for seed enhancement; seed colouring, seed treatment devices, visit to seed processing plant etc.

Reference

AGRAWAL R. L., 1996, Seed Technology, Oxford and IBH Publicity Company, New Delhi.

Basra, A.S. (Ed.). 1995. Seed Quality: Basic Mechanisms and Agricultural Implications. Food Product Press, NY.

Basra, A.S. 2006. Handbook of Seed Science and Technology. Food Product. Press, NY Bench, A.L.R. & Sanchez, R,A., 2004. Handbook of Seed Physiology. Food Product Press, NY/ London.

Copland, L.O. & McDonald, M,B. 2004. Seed Science and Technology. Kluwer Acad.

Kalloo, G,, Jain, S,K,, Vari, A,K, & Srivastava, U. 2006. Seed: A Global Perspective. Associated Publishing Company, New Delhi.

K.K. Sharma, U.S. Singh, Pankaj Sharma, Ashish Kumar and Lalan Sharma, 2015. Seed treatments for sustainable agriculture-A review. Journal of Applied and Natural Science 7 (1) : 521 – 539 .

Parvatha Reddy, 2013. Recent advances in crop protection. Springer India.

SST 608 ADVANCES IN SEED SCIENCE RESEARCH (1+1)

Theory : 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. Modem techniques for identification of varieties and hybrids; principles and procedures of electrophoresis, machine vision technique, DNA fmgerprinting 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). Detection and identification of seed borne fungi, bacteria, viruses, nematodes and insect pests through advanced techniques like ELISA, PCR based techniques etc.

Practical : Advanced techniques on seed science research, seed genetic purity testing by various biochemical and molecular markers, Testing of GM seeds. Demonstration of ELISA and PCR techniques. Production of synthetic seeds, seed encapulation. Visit to the R&D units of seed genetic purity testing etc.

Reference

Bench, A.L.R. & Sanchez, R.A., 2004. Handbook of Seed Physiology. Food Product Press.

Black, M. & Bewley, J.D., (Eds.). 2000. Seed Technology and its Biological Basis. Sheffield Academic Press. Ny/London.

Nicolas, G., Bradford, K.J., Come, D. & Pritchard, H.W., 2003. The Biology of Seeds, Recent Research Advances. CABI.

Journals

Asian Seed (bi-monthly), Asia and Pacific Seed Association, Bangkok.

Seed Research (half yearly), Indian Society of Seed Technology, Indian Agricultural Research Institute, New Delhi.

Seed Science and Technology (Quarterly), International Seed Testing Association, Zurich, Switzerland.

Seed Science Research (Quarterly), Cambridge University Press and International Society for Seed Science, UK

Seed Tech News, Bulletin (monthly), Indian Society of Seed Technology, Indian Agricultural Research Institute, New Delhi.

SOIL SCEINCE AND AGRICULTURAL CHEMISTRY

SAC 601 INSTRUMENTAL METHODS OF ANALYSIS (1+1)

Theory : Theory and application of physicochemical methods used in analytical chemistry. Electrochemical methods-Potentiometry, pH measurements, potentiometric titration. Conductometry: Conductivity measurements, conductometric titrations. Optical methods-Nature of electromagnetic radiation, interaction ofEMR with matter, Beer-Lamberts Law, spectrometry, nephelometry, turbidometry, flame photometry/ Atomic absorption spectroscopy.

ICP, Mass spectroscopy Principles and applications of X-ray diffraction; Polarimetry-optical activity, dextro and levo rotation and specific rotation. Extraction methods-Partitoning, distribution ratio, single extraction, multiple extraction and counter current extraction. Chromatography-classification of chromatographic techniques, partition chromatography, adsorption chromatography and gas chromatography and high performance liquid chromatography. Use of electron microscopy and its application in agriculture.

Practical : Electrochemical methods pH meters, potentiometric titrations, conductivity bridge and conductometric titration. Optical methodscolorimeters, spectrometers, nepholometers, turbidometers, flame photometers, atomic absorption spectrophotometer, ICPS, Polarimety-Optical activity, dextro and levo rotation, specific rotation. Chromatography-Thin layer chromatography, gas chromatography and HPLC. Electron microscope and use in clay mineralogy. Visit to important local laboratorieslike IISc, IIHR, IRC and ISRO

SAC 602 TRACER TECHNIQUES IN SOIL AND PLANT STUDIES (1+1)

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; principles and use of mass spectrometer; application of isotopes in studies on organic matter, nutrient transformations, 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 : Storage and handling of radioactive materials, Determination of halflife 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/ 652n, Use of neutron probe for moisture determination, Sample preparation and measurement of 15N enrichment by mass spectrophotometery / emission spectrometry

References

Stable isotopes in plant nutrition, Soil fertility and Environmental studies, IAEA

Stable isotope Techniques in the Study of Biological processes and functioning of Ecosystems Murray unkovich et al

Use of nuclear techniques in studies of soil plant relationships Hardarson,

Nitrogen use efficiency in sandy soil using 15 N tracer techniques Mamdoh Mohamed Hamed Lamy, Lambert

Radioisotopes in Biology (Practical Approach Series) 2nd Edition Robert J Slater

Isotopes: Principles and applications 3rd Edition Gunter Feaure and Teresa M Mensing

SAC 603 REMOTE SENSING AND GIS TECHNIQUES FOR SOIL AND CROP STUDIES (1+1)

Theory : Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter. Sensor systemscamera, 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.

References

Nature and properties of soils Nyle C Brady and Ray R Weil
Remote sensing, Third edition Robert A Schowengerdt
Remote sensing for geoscientists Gary L Prost
GIS Applications in Agriculture Francis J Pierce and David Clay
Application of Remote Sensing in Agriculture M.D. Steven and J.A. Clark
Remote sensing for agriculture Prof Ashton Paalman

SAC 607 PHYSICAL CHEMISTRY OF SOILS (1+1)

Theory : Colloidal chemistry of inorganic and organic components of soilstheir 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).

Practical : Extraction of total constituents in soils, Determination of buffering capacity of soil, Determination of cation exchange and anion exchange, Determination of adsorption of isotherms, Determination of quantity and intensity of potassium, Determination of phosphate potentials in soils, Calculation of layer charges.

Reference

Soil Physical Chemistry 2nd Edition Donald Sparks
Soil Chemical analysis Advanced Course M.L. Jackson
Soil and Water Chemistry An Integrative Course M.E. Essington
Essentials of Physical chemistry Arun Bahl Et al

SAC 610 ADVANCES IN SOIL FERTILITY (1+1)

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 userecommendations; 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.

Practical : Soil testing methods for nutrients, F ertliser recommendations for crops by soil testing, STCR approach, DRIS, Biochemical changes in plants under nutrient deficiency levels. Site specific nutrient management. Integrated nutrient management

Reference

Soil Fertility Theory and Practice J.S. Kanwar et al
Soil management of tropical soil fertility Womer, PL and Swift MJ
Principles of plant nutrition Mengel K and Kirkby EA
Fundamentals of soil science ISSS, New Delhi
Soil chemical analysis Jackson M L
Fundamental principles of soil science Dipak sarkar and Abhijit Haldar
Soil fertility Henry DF Boyd GE 2nd ed
Nature and properties of soils Nyle C Brady and Ray R. Weil

SAC 611 LAND USE PLANNING AND WATERSHED MANAGEMENT (1+1)

Theory : Concept and techniques of land use plannipg; factors governing present land use. Land evaluation methods and soil-site suitability evaluation for different crops; land apability 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.

Practical : Determination of different soil erodibility indices-suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, perc'olation ratio, raindrop erodibility index, Land capability classification, Fertility capability classification, Irrigability classification, Visits to a watersheds

References

Remote Sensing and GIS Approach for prioritization of watershed Sharma Shailesh Kumar et al

Watershed management planning using remote sensing and GIS Rajnikumar patel

Integrated land use planning for sustainable Agriculture and Rural Development M.C. Rao et al

Developments in soil classification, land use planning and policy implication Shahid shabbier A et al

SAC 613 RECYCLING OF ORGANIC RESOURCES AND MANAGEMENT (1+1)

Theory : Organic resources-definition, classification, characteristics, composition, criteria for recycling of organic resources, Major degradation pathways of organic resources. Soil organic matter pools, mineralisation. Composting-history, definition, objectives, essentials, technologies, types, advantages and limitations. Biochemical changes during decomposition, relationship between ligninun, cellulose, poly phenols and other constituents, factors influencing compo sting, quality standard of compost. Agro-industrial organic resources-characteristics and bioconversion technologies. Crop residue management, Vermitechnology,

Biofertilizersinfluence on soil and plant growth. Sewage treatment, sludge chemistry, uses and after effects, Integrate nutrient management, organic farming, biodynamic farming-salient features and utility.

Practical : Recent technique in compost making and enriched compost. Visit to biogas and sewage and compost plants-acquaint with techniques adopted. Collection of raw materials, biogas spent slurry, sludge and compost. Manurial constituent analysis of different organic resources.

References

Soil Enzymology in the recycling of Organic wastes and environmental Restoration Carmen Trasar Cepeda et al
Integrated waste management Volume II Sunil Kumar
Organic waste recycling, 2nd Edition Chongrak Polprasert
Management of organic waste Sunil Kumar and Ajay Bharati

HORTICULTURAL STATISTICS

HST 601 APPLIED REGRESSION ANALYSIS (2+1)

Theory : 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. Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions. Problem of correlated errors; Auto correlation; Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multicollinearity; 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. Heteroscedastic models, Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomials.

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.

HST 602 MULTIVARIATE ANALYSIS (2+1)

Theory : 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. Wishart distribution and its simple properties. Hotelling's T2 and Mahalanobis D2 statistics. Null distribution of Hotelling's T2. Rao's U statistics and its distribution. Wilks lambdacriterion and statement of its properties. Concepts of discriminant analysis, computation of linear discriminant function, classification between k (e" 2) multivariate normal populations based on LDF and Mahalanobis D2. Principal Component Analysis, factor analysis (simple and multi factor models). Canonical variables and Hierarchical clustering. Single and Complete linkage methods. 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.

HST 603 DESIGN OF EXPERIMENTS 2+1

Theory : Elements of linear estimation, Gauss Markoff Theorem, relationship between BLUEs and linear zero-functions. Aitkens transformation, test of hypothesis, analysis of variance, partitioning of degrees of freedom. Orthogonality, contrasts, mutually orthogonal contrasts, analysis of covariance; Basic principles of design of experiments, uniformity trials, size and shape of plots and blocks. Basic designs-completely randomized design, randomized complete block design and Latin square design; orthogonal Latin squares, mutually rthogonal Latin squares (MOLS), Youden square designs, Graeco Latin squares. 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. Factorial experiments, confounding in symmetrical factorial

experiments (2n and 3n series), partial and total confounding, fractional factorials, asymmetrical factorials. 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; 2n, 3n 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.

HST 604 REGRESSION ANALYSIS 2+1

Theory : Simple and Multiple linear regressions: Least squares fit, Properties and examples. Polynomial regression: Use of orthogonal polynomials. 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. 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. 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. 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.