UNIVERSITY OF HORTICULTURAL SCIENCES

BAGALKOT

COURSE SYLLABUS
FOR
MASTER 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

Masters Degree Programme

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CONTENTS

FRUIT SCIENCE

Sl.No	Course Title	Course No.	Credit hrs.
	A. CORE COURSES		
1.	Tropical Fruits	FSC-501	2+1
2.	Sub - Tropical Fruits	FSC-502	2+1
3.	Temperate fruits and nuts	FSC-503	2+0
4.	Growth and Development of fruit crops	FSC-504	2+1
5.	Breeding of Fruit crops	FSC-505	1+1
6.	Nutrition of Fruit crops	FSC-506	2+1
		Total	**16**
	B. OPTIONAL COURSES (Minimum 4 Credits)		
1.	Propagation and Nursury management of Fruit crops	FSC-507	2+1
2.	Canopy Management in Fruit crops	FSC-508	1+1
3.	Principles and Practices of Dryland Horticulture	FSC-509	1+1
4.	Orchard Management	FSC-510	1+1
5.	Principles and practices of water management in horticultural crops.	FSC-511	1+1
6.	Organic production of Fruit crops	FSC-512	1+1
7.	Bio-diversity and Conservation of Fruit crops	FSC-513	2+1
8.	Bio-technology of Fruit crops	FSC-514	1+1
9.	Plant growth regulators in fruit crops	FSC-515	1+1
1o	Under exploited fruit crops	FSC-516	1+1
11.	Systematic Pomology	FSC-517	1+1
12.	GAP for Horticulture crops	FSC-518	1+0
13.	Climate change in Horticulture	FSC-519	1+1
		Total	**27**

A. CORE COURSES

FSC- 501 TROPICAL FRUITS (2 + 1)

Theory: Importance, history, origin, area, distribution, botany, taxonomy, varieties and their classification. Climatic and soil requirements, propagation, root stocks and problem of multiplication. Establishment of commercial orchards, planting and aftercare. Nutrition management, nutritional disorders, training, pruning, irrigation, weed control and intercropping. Vegetative and reproductive phases, fruit set and fruiting.Techniques for high productivity, Physiological disorders causes and remedies, Pest, diseases and their management, Post-harvest handling. Industrial and export potential, Agri. Export Zones (AEZ) and industrial supports of the following crops

Mango, Banana, Papaya, Sapota, Pineapple, Jackfruit, *Annonaceous* crops, Jamun, Tamarind, Avacado, Passion fruit, Mangosteen, Carambola, Bilimbi.

Practicals : Study of varieties and species, Propagation methods, Planting and aftercare, Nutrient diagnosis, Study of flowering and fruit set, Identification of pests and diseases and their management. Harvesting and handling. Project preparation for establishment of commercial orchards. Visit to progressive orchards and research centre.

Suggested Reference:

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

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

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

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

FSC- 502 Sub - Tropical Fruits (2 + 1)

Theory: Importance, history, origin, area, distribution, botany, taxonomy, varieties and their classification. Climatic and soil requirements, propagation, root stocks and problem of multiplication. Establishment of commercial orchards, planting and aftercare. Nutrition management, nutritional disorders, training, pruning, irrigation, weed control and intercropping. Vegetative and reproductive phases,

fruit set and fruiting.Techniques for high productivity, Physiological disorders causes and remedies, Pest, diseases and their management, Post-harvest handling. Industrial and export potential, Agri. Export Zones (AEZ) and industrial supports of the following crops.

Citrus, Grapes, Guava, Pomegranate, Fig, Ber, Aonla, Litchi, Datepalm, West Indian cherry.

Practicals : Study of varieties and species, Propagation methods, Planting and aftercare, Nutrient diagnosis, Study of flowering and fruit set, Identification of pests and diseases and their management. Harvesting and handling. Project preparation for establishment of commercial orchards. Visit to progressive orchards and research centre.

Suggested Reference:

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

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

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

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

FSC- 503 Temperate Fruits and Nuts (2 + 0)

Theory: Importance, history, origin, area, distribution, botany, taxonomy, varieties and their classification. Climatic and soil requirements, propagation, root stocks and problem of multiplication. Establishment of commercial orchards, planting and aftercare. Nutrition management, nutritional disorders, training, pruning, irrigation, weed control and intercropping. Vegetative and reproductive phases, fruit set and fruiting.Techniques for high productivity, Physiological disorders causes and remedies, Pest, diseases and their management, Post-harvest handling. Visit to orchards / research centre.

Apple, Pear, Peach, Plum, Cherries, Strawberry, Kiwifruit, Walnut, Almond, Apricot, Pecan nut, Pistachionut.

Suggested Reference:

Mitra, S.K., Rathore D.S., and Bose, T.K.991, Temperate fruits, Horticulture and Aallied Publishers, Kolkatta

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

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.

FSC- 504 Growth and Development of fruit crops (2 + 1)

Theory: Growth and development- definition, parameters of growth and development, growth dynamics, morphogenesis. environmental impact on growth and development, effect of light, photosynthesis and photoperiodism vernalisation, effect of temperature, heat units, thermoperiodism.

Plant growth substances involved in growth regulation; history, development and nomenclature, mode of action and their physiological effects of different classes of growth substances - auxins, gibberellins, cytokinins, inhibitors, ethylene, abscisic acid, *etc.* Morphogenesis - differential growth, growth correlations, apical dominance and their significance as applicable to fruit crops. Use of tissue culture in the study of Morphogenesis, Physiology of dormancy in buds and seed**s**, juvenility, abscission and senescence. Use of growth regulators in regulation of these processes.

Physiology of flowering in fruit crops - relationship with photoperiod and temperature (Vernalization); nature of floral stimulus; hormonal control of flowering and sex expression. Physiological factors associated with fruit set and development; hormonal relation. Fruit ripening- physiological mechanism. Chemical regulation of fruit growth and ripening. Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth and development.

Practicals: Understanding dormancy mechanisms in seeds and stratification of seeds, Study of growth and development patterns, techniques of growth analysis, evaluation of photosynthetic efficiency under different environments, study of growth regulator functions,hormone assays, understanding ripening phenomenon in fruits, study of impact of training and pruning on growth and development, study of chemical manipulations on growth and development, understanding stress impact on growth and development. Visit to research centers.

Suggested Reference:

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

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

Leopold, A.C. and P.E. Kriedman, 1985. Plant Growth and Development. 3rd Ed. Mc Graw Hill, New York.

FSC- 505 Breeding of Fruit crops (1 + 1)

Theory: Importance, problems and solutions in breeding of fruit crops. Botany, origin, centres of diversity and distribution of fruit species. History of improvements/ developments. Methods of breeding - Introduction, selection, identification and selection of mutants, bud-sprouts, chimeras and their perpetuation by vegetative propagation. Collection and maintenance of Germplasm of varieties and related species. Breeding behaviour of fruit crops. Floral biology, pollination problems, incompatibility systems.

Principles and methods of breeding, inheritance, hybridization techniques and selection procedures; male sterility and its induction and utilization, use of gene markers; use of polyploidy in developing seedless fruits and dwarfing rootstocks; mutation breeding by use of irradiation and chemical mutagens. Inbreeding, depression etc. Breeding for resistance to pests/diseases .Methods of early testing of progenies by use of grafting techniques and growth regulators. Prospects of genetic engineering and biotechnology in improvement of fruit crops. The following crops will be covered

Mango, banana, citrus, grape, guava, sapota, papaya, pomegranate, apple, aonla and breeding achievements.

Practicals : Description and classification of related species and varieties of fruit crops. Identification of sources of desirable characters in germplasm. Study of floral biology and hybridization techniques. Visit to research centres may be arranged.

Suggested Reference:

Chadha, K.L. and O.P. Pareek (Ed.) 1993. Adavances in Horticulture, Fruit Crops volI. Malhotra Publishing House, N. Delhi.

FSC- 506 NUTRITION OF FRUIT CROPS (2 + 1)

Theory: Importance and history of nutrition of fruit crops. Primary, secondary and micro elements in nutrition. Role of individual elements on growth and fruiting of fruit crops.Diagnostic methods for determining nutrition requirements - amount of nutrients removed by crop/plant, foliar diagnosis, visual symptoms of deficiencies/disorders, tissue/plant analysis, soil analysis *etc*. Evaluation of nutrient status in orchards. DRIS concept of nutrition. Root studies - root distribution as criteria for determining amount and replacement of nutrients. Nutrient requirements of fruit crops. Methods of nutrients application - soil, foliar *etc.* Manures and manuring , organic and green manuring and fertilizer application. Need based nutrition, splits and time of application. Soil pH and nutrient availability, soil salinity and other antagonistic factors. Use of soil amendments, salt tolerant crops etc. Special problems - nutritional disorders and developments done.

Practicals : Study of diagnostic techniques for determining nutrient status of fruit crops. Study of root distribution, leaf sampling techniques. Study of equipments used in nutrient analysis. Chemical analysis of different nutrients. Study of deficiency symptoms. Nutrient culture studies, foliar nutrition. Visit to long-term fertilizer experimental plots in research centres.

Suggested Reference:

Chudawat, B.S. Fruit Nutrition Management of Fruit Crops. Agritech Publishing Company, Udailpur.

Epstein, E. 1972. Mineral Nutition of Plants-Principles and Perspectives. John Wiley and Sons, London.

B.OPTIONAL COURSES

FSC- 507 PROPAGATION AND NURSERY MANAGEMENT OF FRUIT CROPS (2+1)

Theory: Principles of plant propagation: Sexual and asexual methods of propagation. Principles, factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth. Seed quality, packing, storage, certification, testing. Anatomical and physiological aspect of propagation through cuttage, layerage and graftage. Compatibility in graftage. Physiology of dwarfing rootstock and dwarfing rootstock of important fruit trees. Role of plant growth regulators in raising of

seedlings and rooting of cuttings and layers. Role of nucellar embryony, apomixes and tissue culture. Techniques of cuttings, layering, budding, grafting and micrografting (STG).

Planning of a nursery unit. Raising of nursery plants and their after care. Selection, certification and maintenance of the mother plants and budwood nurseries. Use of modern propagation structures like mist chambers, low cost polyhouses, low cost tunnels and study of bottom heating techniques. Hardening techniques, Media/soil mixtures, containers, use of machineries in nursuries and soil sterilisation. Lifting, packing, transportation, marketing of nursery plants. Economics of raising nursery and management of different fruit crops. Nursery acts.

Practicals : Media/soil mixture, containers and soil sterilisation. Use chemicals for seed treatment and sowing. Preparation of nursery beds, poly bags, seed pans thumbpole for raising seedlings, stratification and scarification of seeds and use of tetrazolium salts for germination tests. Identification of nucellar seedlings, practice of different asexual method of propagation, *viz.,* cuttage, layering, budding, approach, veneer and softwood grafting. Use of plant growth regulators in propagation of plant materials. Use of mist chambers, modern propagation structures, low cost polyhouses, low tunnels and bottom heating techniques. Selection, lifting, packing, transportation and marketing of nursery plants. Economics of raising nurseries. Visit to local commercial/private nurseries.

Suggested Referece: Bose, T.K. (Ed). 1986. Plant Propagation, Naya Prakosh, Calcutta

Hartmann and Kesslar. 1997. Plant Propagation-Principles and Practices. Prentice Hall of India, Pvt. Ltd. Bombay.

FSC- 508 CANOPY MANAGEMENT IN FRUIT CROPS (1+1)

Theory: Canopy, canopy management, its importance and advantages, factors affecting canopy types and structures with special emphasis on canopy manipulation for optimum utilisation of light, light interception and distribution in different types of tree canopies. Canopy classification, canopy management through rootstock, scion, plant growth inhibitors, Training and pruning intensity. Types of supporting structures for training, High density plantations. Canopy development and management in grapes, passion fruit, mango, guava, pomegranate, citrus, ber and temperate fruits. Canopy management in relation to growth, flowering, fruiting and fruit quality.

Practicals : 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 Reference:

Chadha, K.L. and S.D. Shikhamany: 1999. The Grape, Improvement, Production and Post Harvest Management. Malhotra Publishing House, New Delhi.

FSC- 509 PRINCIPLES AND PRACTICES OF DRYLAND HORTICULTURE (1+1)

Theory: Definition, importance and limitation of dry land horticulture, present status and future scope. Constraints encountered in dry lands. Agro-climatic features in rain shadow areas, scarce water resources, high temperature, soil erosion, run-off losses *etc.*

Techniques and management of dry land horticulture. Watershed development, soil and water conservation methods - terraces, contour bunds, etc. Methods of control and impounding of run-off water - farm ponds, trenches, macro catch pits, *etc., in-situ* water harvesting methods, micro catchment, different types of tree basins *etc*. Methods of reducing evapotranspiration, use of shelter belts, mulches, antitranspirants, growth regulators, *etc.* Water use efficiency - need based, economic and conjunctive use of water, micro systems of irrigation *etc*.

Selection of plants having drought resistance. Special techniques, planting and after care - use of seedling races, root stocks, *in-situ* grafting, deep pitting/planting, canopy management *etc*.

Practicals : Study of rainfall patterns. Contour bunding/trenching, micro catchments, soil erosion and its control. Study of evapotranspiration, mulches and micro irrigation systems. Special techniques of planting and aftercare in dry lands. Study of morphological and anatomical features of drought tolerant fruit crops.

Suggested Reference:

Chadha, K.L. and O.P. Pareek (Ed). 1993 Advances in Horticulture, vols. I-Iv. Fruits, Malhotra Publishing House, New Delhi.

FSC- 510 ORCHARD MANAGEMENT (1+1)

Theory: Definition of orchards, Importance and scope of orchard management, types of orchards, Planning, design and layout of orchards. Selection of crops,

varieties and procurement of quality planting material. Establishment of orchards, Soil management practices, Cropping systems in tropical, sub-tropical, temperate and silvi-horticultural plants, multistoried cropping system.Soil and water conservation practices in fruit orchards. Management of problematic soils. water, nutrient and weed management. Training, pruning and management of bearing orchard. Mechanisation in orchard, Harvesting, disposal and marketing of orchard produce, book keeping and accounting.

Practicals : Planning, layout and design of different orchards, planting systems. Study of different soil management practices, *in-situ* moisture conservation. Study of irrigation system including design and layout.weed management, Estimation of cost of cultivation of fruit production. Records and maintenance of records. Visit to progressive fruit orchard.

Suggested Reference:

Arakeri, H.R. and L. Donahue roy, 1984. Principles of Soil conservation and Water Management . Oxford and IBH Publishing co, New Delhi.

FSC- 511 PRINCIPLES AND PRACTICES OF WATER MANAGEMENT IN HORTICULTURAL CROPS (1+1)

Theory: Water and its role in plants, Importance of irrigation, water resources and their utilization, water requirement of the fruit crops, soil-plant-water relationships,Soil water movement, soil moisture stress and excess in relation to growth and productivity of fruit crops. Soil moisture extraction pattern, moisture contents and conservation methods.

Determination of irrigation needs in relation to physiological stages of plant development, need based irrigation. Irrigation in rainfed orchards. effects of excess water-salinity problems *etc.*

Quality and measurements of irrigation water. Sources and distribution pattern of irrigation water. Estimation of water requirement of different fruit crops. Consumptive and water use efficiency, quantity and frequency of irrigation. Methods of irrigation and layout of different systems. Micro systems of irrigation. Fertigation, Water management in controlled environment.

Practicals : Study of water requirements of different crops and designing cropping pattern in relation to water requirements. Measurement of Soil moisture, Methods of irrigation, Planning, Layout and installation of drip irrigation system, drainage systems.

Suggested Reference:

Chadha, K.L.and O.P. Pareek (Ed). Advances in Horticulture. Vol.2 Malhotra Publishing House, New Delhi.

FSC- 512 ORGANIC PRODUCTION OF FRUIT CROPS (1+1)

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 fruit production, role of biofertilizers, biodynamics and the recent developments.EM technology and its impact in organic fruit production, indigenous practices of organic farming, sustainable soil fertility management, weed management practices in organic farming, biological/natural control of pests and diseases, 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 fruit production and export, IFOAM and global scenario of organic movement, post-harvest management of organic produce.

Practicals: Features of organic orchards, working out conversion plan, Input analysis - manures, nutrient status assessment of manures, biocomposting, biofertilizers and their application, panchagavya preparation and other organic nutrients application, methods of preparation of compost, vermicompost, green manuring, preparation of neem products and application, BD preparations and their role, EM technology and products, biological/natural control of pests and diseases, soil solarization, frame work for GAP, case studies, HACCP analysis, residue analysis in organic products, documentation for certification, visit to organic fruit orchards

Suggested Reference

Palaniappan & Annadurai, 2008, Organic farming – Theory and practice Scientific Publ.

Lampkin N & Ipswich, 1990. Organic farming. Farming Pres. London.

FSC- 513 BIO-DIVERSITY AND CONSERVATION OF FRUIT CROPS (1+1)

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 covered Mango, sapota, citrus, guava, banana, papaya, grapes, jackfruit, custard apple, ber, aonla, apple, litchi.

Practicals: 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 centers of PGR activities.

Suggested Reference:

Frankel,O.H. and J.G. Hawkes, 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press. U.K.

FSC- 514 BIOTECHNOLOGY OF FRUIT CROPS (1+1)

Theory: Biotechnology and its scope in horticultural crops, influence of plant material, physical factors, chemical factors, growth regulators on growth and development, cell organelles, organ culture, calluses, somaclonal identification electrophoresis, embryo rescue of recalcitrant species; *in vitro* mutation, epigenetic variant and micrografting, use of *in vitro* production of secondary metabolites, marphogenesis, nutrition and regeneration of tissues, establishment of tissue cultured plants, hardening and field transfer, gene cloning, cloning vectors, recombinant DNA technology, gene transfer, transgenic plants, achievements in fruits, application of molecular techniques for identification and characterisation of different types of fruits, marker aided selection and breeding for QTLs.

Practicals : An exposure to biotechnology, laboratory, inoculation of explants for clonal propagation, callus culture, regeneration of plantlets from callus, sub-culturing techniques on another, ovule, embryo culture, somoclonal variation, mutation induction *in vitro* fusion technique, wide hybridisation, embryo rescue, gene transfer, development of transgenic plants, development of protocols for mass multiplication of fruit and plantation crops.

FSC- 515 PLANT GROWTH REGULATORS IN FRUIT CROPS (1+1)

Theory: History, nomenclature, role and physiological effects of auxins, gibberllins, cytokinins, inhibitors and growth retardant. Methods of application of growth regulators. Factors influencing absorption, translocation, degradation. Use of growth regulators in plant propagation, seed and bud dormancy, apical dominance, flower bud initiation, regulation of flowering, flower and fruit thinning, fruitset and fruit development, fruit drop and parthenocarpy, fruit ripening and quality improvement in fruit and plantation crops, *viz.,* Mango, citrus, grapes, banana, pineapple, Pomegranate, litchi.=

Practicals :Preparation of growth regulator solutions and other commercially available formulation. Application in plant propagation, prevention of flower and fruit drop, induction of parthenocarpy, fruitset, fruit thinning and fruit ripening and quality improvement.

Suggested Reference:

Leopold, L.C. and P.E. Kriedemann 1998, Plant Growth and Development Tata Mc Graw Hill Publishing Company, New Delhi.

FSC- 516 UNDER EXPLOITED FRUITS CROPS (1 + 1)

Theory: Importance, history, origin, area, distribution, botany, taxonomy, varieties and their classification. Climatic and soil requirements, propagation, root stocks and problem of multiplication. Establishment of orchards, planting and aftercare. Nutrition management, nutritional disorders, training, pruning, irrigation, weed control and intercropping. Exploration of production and processing potentials, Physiological disorders causes and remedies, Pest, diseases and their management, Post-harvest handling of the following crops

Bael, Durian, Rambutan,karonda,woodapple,carambola, breadfruit, Palmyra palm, Manila Tamarind, Lasoda, Langsat, Roseapple, khejri, Marking nut, Hog plum, Mulberry, Phalsa.

Practicals : Study of varieties and species, Propagation methods, Planting and aftercare, Nutrient diagnosis, Study of flowering and fruit set, Identification of pests and diseases and their management. Harvesting and handling. Project preparation for establishment of commercial orchards. Visit to progressive orchards and research centre.

Suggested Reference:

Bose, T.K. and S.K. Mitra (ed). 1990 Tropical and Sub tropical Frits. Naya Prokash, Calcutta

FSC- 517 SYSTEMATIC POMOLOGY (1 + 1)

Theory: Systematic Pomology and its significance; general principles of classification and nomenclature; salient features of international code of nomenclature for fruit crops; botanical description of families, genera and species covering various tropical, sub-tropical and temperate fruits and nuts upto varietal level; cytological status of various fruit plants; descriptors for varieties of important fruit crops. Description, classification and identification of fruit species and varieties with special reference to important fruits grown in India.

Practicals : Methods used in describing flowering plants; identification, description and classification of fruit species and varieties; survey, collection and identification of allied species and genera locally available; methods of preparation of herbarium specimens.

Suggested Reference:

Bose, T.,K, and S.K. Mitra (Eds). 1990. Fruit: Tropical and Sub-Tropical. Naya Prokash. Calcutta.

FSC- 518 GAP FOR HORTICULTURAL CROPS (1 + 0)

Genesis of GAP – definition/description, components listed by FAO, frame work. Management of site history and soil, crop and fodder production, IPM, INM, IWM, irrigation water, crop production and protection. Identification of ways of improving the productivity, profitability, and resource efficiency, harvest and post-harvest handling.Animal production, product certification, animal waste management, animal health and welfare, harvest. On farm processing, storage, energy and waste management, human health, welfare, safety, wild life benefits. Institutions involved in GAP certification. Indian agencies, EUREPGAP (European Retail Producers Group-Good Agricultural Practices), EUREP *etc.*

FSC- 519 CLIMATE CHANGE IN HORTICULTURE (1 + 0)

Theory: Introduction to climate change. Factors directly connected to climate change, average temperature, change in rainfall amount and patterns, rising atmospheric concentrations of CO_2, pollution levels such as tropospheric ozone, change in climatic variability and extreme events like receding of glaciers in Himalayas. Sensors for climate registration and crop monitoring,

phytomonitoring and biosensors, plants response to the climate changes, premature bloom, marginally overwintering or inadequate winter chilling hours, insect pests, longer growing seasons and shifts in plant hardiness for perennial fruit crops, flowering plants and other plant species. Impact of climate changes on invasive insect, disease, weed, pests, horticulture yield, quality and sustainability, climate management in field production – mulching - use of plastic- windbreak- spectral changes- frost protection. Climate management in greenhouse- heating - vents - CO_2 injection - screens - artificial light. Climate management for control of pests, diseases, quality, elongation of growth and other plant processes- closed production systems around the world. Special protected cultivation now and in the future, growth chambers, production in space, biosphere, future aspects of closed production, future greenhouse, use of LED as artificial light, future sensor types etc. clean development mechanism, role of tropical trees.

Suggested Reference:

Chadha, K.L.and O.P. Pareek (Eds). Advances in Horticulture. Vol.2 Malhotra Publishing House, New Delhi.

VEGETABLE SCIENCE

Sl. No.	Code	Course Title	Credits
		A.Core Course	
1	VSC 501	Fundamentals of vegetable production	2+1
2	VSC 502	Production Technology of vegetable crops-I	2+1
3	VSC 503	Production Technology of vegetable crops-II	2+1
4	VSC 504	Principles and methods of vegetable Breeding	2+1
5	VSC 505	Seed production technology of vegetable crops	1+1
6	VSC 506	Organic vegetable production technology	1+1
		Total	**16**
		B. Optional courses (Minimum 4 Credits)	
7	VSC 507	Nutrition of vegetable crops	2+1
8	VSC 508	Protected cultivation of vegetables	1+1
9	VSC 509	Water management in vegetable crops	1+1
10	VSC 510	Vegetable based cropping system	2+0
11	VSC 511	Breeding of vegetable crops-I	2+1
12	VSC 512	Breeding of vegetable crops-II	2+1
13	VSC 513	Fundamentals of vegetable processing	1+1
14	VSC 514	Systematics of vegetable crops	1+1
15	VSC 515	Production technology of under exploited vegetable crops	1+1
		Total	**21**

B. CORE COURSE

VSC 501 FUNDAMENTALS OF VEGETABLE PRODUCTION (2+1)

Theory

UNIT I : Importance of vegetables, area and production in state, India and world, types of vegetable gardening, classification of vegetables.

UNIT II : Environmental factors (limiting factors) and their role in vegetable production.

UNIT III :Soil requirement - soil texture, structure and soil reaction (pH). Methods of vegetable production - outdoor, greenhouse, plastic tunnels etc. Principles governing vegetable production under glass and plastic houses. Nursery techniques in vegetable crops - seed dormancy, handling pre-germinated seeds, fluid drilling, structures used.

UNIT IV : Nutrient requirements - critical levels, physiological disorders/ deficiencies, corrections; manures, chemical fertilizers and their response.

UNIT V :Water requirements and irrigation practices. Crop rotation, crop succession, inter and mixed cropping. Aftercare - weeds .

UNIT VI : Role of plant growth substances in vegetable production. Harvesting and post harvest technology for vegetable crops.

UNIT VI : Seed production techniques: Isolation, field standards, Seed standards, Seed processing and certification.

Practicals: Nursery techniques - preparation of germination medium (nursery bed). Tests of viability and vigour of seeds. Sowing, seed germination and seedling hardening. Experiment/s to demonstrate the role of environmental factors, essential elements and growth regulators. Identification of important pests and diseases and their management. Study of nutrient deficiencies and their control. Maturity standards for harvesting and post harvest handling. Greenhouse structures for vegetable production.

Suggested Reference:

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

Edmond, J.B., Musser, A.M., and Andrews, F.S., 1964. Fundamentals of Horticulture. Blakiston Co.

Gupta, U.S., (Ed.). 1978, Crop Physiology. Oxford & IBH.

Krishnamoorti, H.N., 1981, Application Plant Growth Substances and Their Uses in Agriculture.Tata-McGraw Hill.

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

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

Fordham, R., and Biggs, A.G., Principles of vegetable crop production...

Katyal, S.L. Vegetable growing in India...

Bose,T.K., and Som, M.G., Kabir, J., Vegetable crops... Shanmugavelu Production technology of vegetable crops

Singh,S.P., Principles of vegetable production

Thompson, H.C., and Kelley,W.C., Vegetable crops...

Yawalkar, K.S. Vegetable crops of India...

Singh,H.P., 2008, Technology interventions in Indian Horticulture-A way ahead. Indian Horticulture, 52(4) :1-9

VSC 502 PRODUCTION TECHNOLOGY OF VEGETABLE CROPS-I (2+1)

Theory: Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/plantingtimes and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operation, weed control, mulching, physiological disorders, harvesting, yield post-harvest management, plant protection measures and seed production of:

UNIT I: Potato

UNIT II : Cole crops: cabbage, cauliflower, knoll-kohl, sprouting broccoli, Brussels sprout

UNIT III :Root crops: carrot, radish, turnip and beetroot

UNIT IV :Bulb crops: onion and garlic

UNIT V: Tapioca and sweet potato

UNIT VI: Peas and broad bean, green leafy cool season vegetables

Practicals: Cultural operations (Nursery preparation, fertilizer application, sowing/transplanting, mulching, irrigation, weed control) of winter vegetable crops and their economics; Experiments to demonstrate the role of mineral elements, plant growth substances and herbicides; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial greenhouse/polyhouse.

Suggested Reference:

Bose, T.K., Kabir J, Maity, T.K., Parthasarathy, V.A., and Som, M.G., 2003, Vegetable Crops.Vols. I-III. Naya Udyog.

Bose, T.K., Som, M.G., and Kabir, J., (Eds.). 2002. Vegetable Crops. Naya Prokash.

Fageria, M.S., Choudhary, B.R., and Dhaka,R.S., 2000, Vegetable Crops:Production Technology. Vol. II. Kalyani.

Gopalakrishanan, T.R., 2007, Vegetable Crops. New India Publ. Agency.

Hazra, P., and Som, M.G., (Eds.). 1999, Technology for Vegetable Production and Improvement. Naya Prokash.

Kalloo, G., and Singh, K (Ed.). 2000. Emerging Scenario in Vegetable Research and Development. Research Periodicals & Book Publ. House.

Shanmugavelu, K.G., 1989. Production Technology of Vegetable Crops. Oxford & IBH.

Singh, D.K., 2007, Modern Vegetable Varieties and Production Technology. International Book Distributing Co.

Singh, N.P., Bharadwaj, A.K., Kumar, A and Singh, K.M., 2004. Modern Technology on Vegetable Production. International Book Distributing Co.

Thamburaj, S and Singh, N., 2004, Vegetables, Tuber Crops and Spices.ICAR.

VSC 503 PRODUCTION TECHNOLOGY OF VEGETABLE CROPS-II (2+1)

Theory: Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operation, weed control, mulching, physiological disorders, harvesting, yield, post harvest managements, plant protection measures, economics of crop production and seed production of:

UNIT I : Tomato, eggplant, hot and sweet peppers

UNIT II : Okra, beans and cowpea

UNIT III: Cucurbitaceous crops: Cucumber, water melon and musk melon

UNIT IV : Gourds, squashes and pumpkins

UNIT V : Green leafy warm season vegetables

Practicals: Cultural operations (Nursery preparation, fertilizer application, sowing/transplanting, mulching, irrigation, weed control) of summer vegetable crops and their economics; study of physiological disorders and

deficiency of mineral elements, preparation of cropping schemes for commercial farms; experiments to demonstrate the role of mineral elements, physiological disorders; plant growth substances and herbicides; seed extraction techniques; identification of important pests and diseases and their control; maturity standards; economics of warm season vegetable crops.

Suggested Reference:

Bose, T.K., Kabir, J., Maity, T,K., Parthasarathy, V.A., and Som, M.G., 2003, *Vegetable Crops*. Vols. I-III. Naya Udyog.

Bose, T.K., Som, G., and Kabir, J., (Eds.). 2002, *Vegetable Crops*. Naya Prokash.

Chadha, K.L., and Kalloo, G., (Eds.). 1993-94. *Advances in Horticulture* Vols. V-X. Malhotra Publ. House.

Fageria, M.S., Choudhary, B.R, and Dhaka, R.S., 2000. *Vegetable Crops:Production Technology*. Vol. II. Kalyani.

Gopalakrishanan, T.R., 2007. *Vegetable Crops*. New India Publ. Agency.

Hazra, P., and Som, M.G., (Eds.). 1999. *Technology for Vegetable Production and Improvement*. Naya Prokash.

Salunkhe, D.K., and Kadam, S.S., (Ed.). 1998. *Hand Book of Vegetable Science and Technology: Production,*

Marcel Dekker and Shanmugavelu, K.G., 1989. *Production Technology of Vegetable Crops*.Oxford & IBH.

Singh, D.K., 2007. *Modern Vegetable Varieties and Production Technology*. International Book Distributing Co.

Thamburaj, S., and Singh, N., (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.

VSC 504 PRINCIPLES AND METHODS OF VEGETABLE BREEDING (2+1)

Theory

Unit I : Importance of vegetable breeding-history and evolutionary aspects of vegetable breeding and vegetable genetic architecture. Centres of origin and their role in crop improvement, germplasm introduction, conservation, exploitation and plant introduction.

Unit II :Breeding systems in vegetable crops, extent of self and cross pollination and factors influencing extent of self and cross pollination in vegetable crops. Self incompatibility systems, male sterility - its induction, maintenance and utilization and Inbreeding depression.

Unit III : Methods - breeding through selection. Pureline selection in vegetable crops.

Population improvement methods and methods to handle segregating generations.

Unit IV : Pedegree and Bulk method of breeding, Back cross breeding and modifications to improve vegetable crops.

Unit V : Mass selection and modifications and recurrent selection methods in vegetable improvement.

Unit VI : Heterosis breeding in vegetable crops: Genetic basis and steps involved in heterosis breeding. Methods of economic F1 seed production.

Unit VII : Role of mutation in vegetable improvement: Methods of induction and identification of mutants. Steps involved in mutation breeding and achievements in vegetable crops.

Unit VIII : Role of ploidy breeding in vegetable improvement: Role euploids and aneuploids in improvement of vegetable crops.

Unit IX : Breeding Vegetable crops for biotic and abiotic stresses and breeding for quality. Role of biotechnology and genetic engineering in improvement of vegetable crops.

Practicals:

Study of floral biology and pollen viability; techniques of crossing and selfing. demonstration of genetic segregation with marker stocks and use of chi-square tests; identification of male sterile and incompatible plants. Demonstration of hybrid vigour, screening procedures for insect pests and disease resistance and for tolerance to environmental stress; methods of inducing mutations and polyploidy. Working out biometrical parameters - chi-square, coefficients of variation, heritability, Genetic gain, hybrid vigour, correlation and regression etc.

Suggested References:

Allard R. W., 1960, Principles of Plant Breeding by Publishers: John, Wiley and Sons, Inc.

Falconer, D. S. and Trudy F.C. Mackay, 1996, Introduction to Quantitative Genetics. Fourth edition. Longman Publishers

G. Kalloo, Vegetable breeding-Vol. I, II and III, Panima Educational Book Agency, New Delhi

Gardner, EJ., Simmons, MJ., Snustad, DP., 1991 Principles of Genetics, Publishers: John, Wiley and Sons, Inc.

Harihar Ram, 1998, Vegetable breeding-Principles and practices –, Kalyani Publishers, Ludhiana, BI-1292, Rajinder Nagar, Ludhiana-141 008,

K.L. Chadha (Chief Editor), Advances in horticulture –, Vol. 5 (vegetable), 7 (potato), 8 (tuber crops), 9 (spices), 11 (media), 12 (aromatic and ornamental plants)

Nagendra andMathura Rai, Heterosis Breeding in vegetable crops, 2006, New India Publishing agency, New Delhi

Sharma JR, 1994, Principles and Practice Plant Breeding, Tata Mc GrawHill Publishing Co. Ltd., New Delhi

Simmonds, N.W.Evolution of crop plants, Longman, London

Singh B. K. and Chaudhary B. D. 1985, Biometrical Methods in Quantitative Genetic Analysis Kalyani Publishers New Delhi.

VSC -505 SEED PRODUCTION TECHONOLGY (1+1)

OF VEGETABLE CROPS

Theory

UNIT I :Definition of seed and its quality, new seed policies; DUS test, scope of vegetable seed industry in India.

UNIT II : Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behaviour, seed development and maturation; methods of hybrid seed production.

UNIT III: Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control.

UNIT IV: Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/ packets), storage and cryopreservation of seeds, synthetic seed technology.

UNIT V: Agro-techniques for seed production in solanaceous vegetables, cucurbits, leguminous vegetables, cole crops, bulb crops, leafy vegetables, okra, veggtatively propagated vegetables.

Practicals: Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, physical purity) and seed health testing; testing, releasing and

notification procedures of varieties; floral biology; rouging of off-type; methods of hybrid seed production in important vegetable and spice crops; seed extraction techniques; handling of seed processing and seed testing equipments; seed sampling; testing of vegetable seeds for seed purity, germination, vigour and health; visit to seed processing units, seed testing laboratory and seed production farms.

Suggested Reference:

Agrawal, P.K., and Dadlani, M., (Eds.). 1992, Techniques in Seed Science and Technology. South Asian Publ.

Agrawal, R.L.,. (Ed.). 1997. Seed Technology. Oxford & IBH.

Bendell, P.E., (Ed.). 1998. Seed Science and Technology: Indian Forestry Species. Allied Publ.

Fageria, M.S., Arya, P.S., and Choudhary, A.K., 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani.

George. R.A.T., 1999., Vegetable Seed Production. 2nd Ed. CABI.

Kumar, J.C., & Dhaliwal, M.S., 1990. Techniques of Developing Hybrids in Vegetable Crops. Agro Botanical Publ.

More, T.A., Kale, P.B., aand Khule, B.W., 1996, Vegetable Seed production Technology. Maharashtra State Seed Corp.

Rajan, S., and Baby, L . Markose., 2007. Propagation of Horticultural Crops. New India Publ. Agency.

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

Singh, S.P., 2001, Seed Production of Commercial Vegetables. Agrotech Publ. Academy.

VSC 506 ORGANIC VEGETABELE PRODUCTION TECHNOLOGY (1+1)

Theory

UNIT I :Importance, principles, perspective, concept and component of organic production of vegetable crops.

UNIT II: Organic production of vegetables crops, *viz.,* solanaceous crops, cucurbits, cole crops, root and tuber crops.

UNIT III: Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.

UNIT IV: Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, Panchagavvya, Biodynamics, preparation etc Pest and disease management in organic farming; ITK's organic farming. Role of botanicals and bio-control agents.

UNIT V: GAP and GMP – Certification of organic products; organic production and export – opportunity and challenges.

Practical : Method of preparation of compost, vermicomposting, biofertilizers, soil solarisation, bio pesticides in horticulture, green manuring ,mycorrhizae and organic crop production, waste management, organic soil amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Reference:

Dahama, A.K., 2005. *Organic Farming for Sustainable Agriculture*. 2nd Ed. Agrobios.

Gehlot, G., 2005, *Organic Farming; Standards, Accreditation Certification and Inspection*. Agrobios.

Palaniappan, S.P., and Annadorai, K., 2003, *Organic Farming, Theory and Practice*. Scientific Publ.

Pradeepkumar, T., Suma, B., Jyothibhaskar, and Satheesan, K.N., 2008. *Management of Horticultural Crops*. New India Publ. Agency.

Shivashankar, K., 1997, *Food Security in Harmony with Nature*. 3rd IFOAMASIA, Scientific Conf.. 1- 4 December, 1997, UAS, Bangalore.

B. OPTIONAL COURSES

VSC 507 NUTRITION OF VEGETABLE CROPS (2+1)

Theory: Mineral nutrition in relation to problematic soils. Organic farming, soil less culture. Fertigation, slow release fertilizers.

UNIT I : Historical background, criteria of essentiality of nutrient elements, clasification of plant nutrients and their role.

Factors affecting nutrition, nutrient uptake and removal; techniques for evaluating nutrient requirements. Symptoms of deficiency and toxicity- their corrective measures. Nutritional disorders. Leaf sampling techniques, nutrient diagnostic techniques (DRIS), index tissue and nutrient standards.

UNIT II : Role of nutrients and their response;

UNIT III :Deficiency and toxicity disorders associated with different minerals, Manures and fertilizers- their composition and availability of essential nutrients.

UNIT IV : Biofertilizers - classification, Vermicuture and vermicomposting. Integrated nutrient management. Effects of nutrient elements on growth, yield and quality.Application of different nutrients; soil and foliar nutrient levels related to crop production of different vegetable crops.

Practicals: Study of diagnostic techniques for determining nutrient status of crops. Preparation of nutrient solutions, sand culture and hydroponics. Identification of deficiency symptoms of different mineral nutrients and their correction, determination of level of toxicity of nutrients. Study of root distribution, leaf sampling techniques. Chemical analysis of different nutrients in different parts of plants and soils. Visit to long term fertilizer experimental plots in research.

Suggested Reference:

Mitra, Sadhu and Bose -Nutrition of vegetable crops

N. Rai and D.S. yadav -Advances in vegetable production

Bose, Kabir, Maity, Parthasarathy and Som- Vegetable crops, Vol. I, II and III

Chadda K.L; - Advances in horticulture, Vol. 5 and 6

Thomson and Kelly -Vegetable crops

Hazra and Som -Technology for vegetable production and improvement Shanmugavelu and Singh - Production technology of vegetable crops

Ware, Swiader and McCollum - Producing vegetable crops

Kirti Singh - Manurial requirements of vegetable crops

VSC 508 PROTECTED CULTIVATION OF VEGETABLES (1+1)

Theory

UNIT I :History, importance and principles of protected cultivation.

UNIT II :Objectives of protected cultivation, structures in protected cultivation, regulatory systems in green/glass houses.

UNIT III :Effects of different growth factors in glass/poly houses on growth and yield of vegetables. Fertigation, Nursery raising under protected structures

like poly tunnels. Different media for growing nursery under cover. Types of benches and containers, training and staking in green houses. Soil less culture. (hydroponics).

UNIT IV :Use of green house for seed production. Problems of growing vegetables, under greenhouse and their remedies. Economics of green/glass house cultivation.

Practicals: Studies on different structures and regulatory systems used for vegetable production under protected conditions. Demonstrations on growth, yield and quality variation in vegetables grown in greenhouses and in open condition. Working out economics of green house/glass house cultivated vegetables. Visit to commercial green house vegetable farms.

Suggested Reference:

Anonymous 2003. *Proc. All India Seminar on Potential and Prospects for Protective Cultivation*. Organised by Institute of Engineers, Ahmednagar. Dec.12-13, 2003.

Chandra S & SomV. 2000. *Cultivating Vegetables in Green House*. *Indian Horticulture* 45: 17-18.

Prasad S & Kumar U. 2005. *Greenhouse Management for Horticultural Crops*. 2nd Ed. Agrobios.

Tiwari GN. 2003. *Green House Technology for Controlled Environment*. Narosa Publ. House.

VSC 509 WATER MANAGEMENT IN VEGETABLE CROPS (1+1)

Theory

UNIT I :History and development of irrigation and water resources in India.

UNIT II : Soil-water-plant relationships. Determination of soil moisture and measurement of irrigation water. Criteria for scheduling irrigations, determination of water requirement for vegetable crops.

UNIT III : Consumptive use, soil moisture extraction pattern and water use efficiency.

UNIT IV : Quality of irrigation water, methods of irrigation. Soil moisture in relation to growth, productivity and quality. Efficient water use techniques.

UNIT V :Drainage and Water management practices for important of vegetable crops.

Practicals:

Determination of soil moisture using various techniques. Measurement of water flow and calculation of irrigation efficiencies. Scheduling of irrigation to vegetable crops by various methods. Working out consumptive use and water requirement of vegetable crops. Preparation of cropping plan based on irrigation requirement of crops. Visit to commercial vegetable farms equipped with modern irrigation systems.

Suggested Reference:

Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. Vegetable Crops. Vols. I-III. Naya Udyog.

Chadha K L & Kalloo G. (Eds.). 1993-94. Advances in Horticulture. Vols. V-X. Malhotra Publ. House.

Hazra P & Som MG. (Eds.). 1999. Technology for Vegetable Production and Improvement. Naya Prokash.

Rana MK. 2008. Scientific Cultivation of Vegetables. Kalyani.

Marcel Dekker. Shanmugavelu KG. 1989. Production Technology of Vegetable Crops. Oxford & IBH.

Singh DK. 2007. Modern Vegetable Varieties and Production Technology. International Book Distributing Co.

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

Singh SP. (Ed.). 1989. Production Technology of Vegetable Crops. Agril. Comm. Res. Centre.

Thamburaj S & Singh N. 2004. Vegetables, Tuber Crops and Spices. ICAR.

Thompson HC & Kelly WC. (Eds.). 1978. Vegetable Crops. Tata Mc Graw Hill.

VSC 510 VEGETABLE BASED CROPPING SYSTEMS (2+0)

Theory

UNIT I :Cropping systems, importance, objectives, scope in the tropics with special reference to Indian conditions.

UNIT II : Principles, definitions of terms multiple, relay and multistoried cropping.

UNIT III : Population and geometry of planting of associated crops.

UNIT IV : Competitive and complementary effects.

UNIT V : Crop intensification in vegetable crops.

Suggested Reference:

Arsanti I. W. and Böhme M. H. 2008. Evaluation of Profitability and Competitiveness of Vegetable Farming Systems in Upland Areas of Indonesia, Proc. IInd on Supply Chains in Transit. Econ. *Acta Hort*., **774**: 49-54

Baniya N. 2008. *Land Suitability Evaluation Using GIS For Vegetable Crops in Kathmandu Valley /Nepal*. A PhD dissertation, Humboldt-University of Berlin, Germany

Dixon J., Gulliver A., Gibbon D. 2001. *Farming Systems and Poverty – Improving Farmers' livelihoods in changing world* – FAO and World Bank, Rome, Italy; Principal Editor Malcolm Hall.

FAO. 1986. *Land evaluation for development*: Food and Agriculture Organization of the United Nations,

Rome, Italy: 4-59 (74p).

T.K. Bose, M.G. Som, J. Kabir Vegetable crops ...

Shanmugavelu Production technology of vegetable crops

S.P. Singh , Principles of vegetable production

H.C. Thompson and W.C. Kelley Vegetable crops ...

Yawalkar, K.S. Vegetable crops of India ..

H.P. Singh, 2008, Technology interventions in Indian Horticulture – A way ahead. *Indian Horticulture*, **52**(4): 1-9.

VSC 511 BREEDING OF VEGETABLE CROPS-I (2+1)

Theory

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

UNIT I - Tomato

UNIT II - Egg plant, hot and sweet pepper

UNIT III - Okra, Amaranthus, French bean, cow pea, dolichos bean

UNIT IV - Cucumber, musk melon, water melon

UNIT V - Ridgegourd, bitter gourd, bottle gourd, Pumpkin and squashes

Practical : Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations; induction of flowering, palanological studies, selfing and crossing techniques in warm season vegetable crops; hybrid seed production of warm season vegetable crops in bulk. Screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops, demonstration of sib-mating and mixed population; molecular marker techniques to identify useful traits in the warm season vegetable crops and special breeding techniques. Biometrics: Diallel analysis and line x tester analysis. Visit to breeding blocks.

Suggested Reference:

Basset MJ. (Ed.). 1986. Breeding Vegetable Crops. AVI Publ.

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

Kalloo G. 1998. Vegetable Breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.

G. Kallo (Ed.), Genetic improvement of tomato –Monograph on TAG 14

Kumar JC & Dhaliwal MS. 1990. Techniques of Developing Hybrids in Vegetable Crops. Agro Botanical Publ.

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

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

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

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

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

VSC 512 BREEDING OF VEGETABLE CROPS-II (2+1)

Theory : Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, molecular marker, genomics, marker assisted breeding

and QTLs, biotechnology and their use in breeding in cool season and tuber vegetable crops-Issue of patenting, PPVFR act.

UNIT I - Potato

UNIT II - Onion and Peas

UNIT III - Cabbage and cauliflower

UNIT IV - Radish, carrot, beetroot and turnip

UNIT V - Sweet potato and tapioca

Practical : Selection of desirable plants from breeding population observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations; induction of flowering, palanological studies, selfing and crossing techniques in cool season and tuber vegetable crops; hybrid seed production of cool season and tuber vegetable crops in bulk. Screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops, demonstration of sib-mating and mixed population; molecular marker techniques to identify useful traits in the cool season and tuber vegetable crops and special breeding techniques. Biometrics: path analysis, scaling test and components of generation means and stability analysis. Visit to breeding blocks.

Suggested Reference:

Basset MJ. (Ed.). 1986. Breeding Vegetable Crops. AVI Publ.

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

Fageria MS, Arya PS & Choudhary AK. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani.

Jones H.A. and L.K. Mann, Onion and their allied –World Book Series, Leonard Hill Books Ltd, London

Kalloo G. 1998. Vegetable Breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.

Kumar JC & Dhaliwal MS. 1990. Techniques of Developing Hybrids in Vegetable Crops. Agro Botanical Publ.

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

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

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

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

VSC 513 FUNDAMENTALS OF VEGETABLE PROCESSING (1+1)

Theory

UNIT I : History of food preservation. Present status and future prospects of vegetable preservation industry in India.

UNIT II : Spoilage of fresh and processed horticultural produce; biochemical changes and enzymes associated with spoilage of horticultural produce; principal spoilage organisms, food poisoning and their control measures. Role of microorganisms in food preservation.

UNIT III : Raw materials for processing. Primary and minimal processing; processing equipments; Laytout and establishment of processing industry, FPO licence. Importance of hygiene; Plant sanitation.

UNIT IV : Quality assurance and quality control, TQM, GMP. Food standards – FPO, PFA, etc. Food laws and regulation.

UNIT V: Food safety – Hazard analysis and critical control points (HACCP). Labeling and labeling act, nutrition labeling.

UNIT VI: Major value added products from vegetables. Utilization of byproducts of vegetable processing industry; Management of waste from processing factory.

UNIT VII :Investment analysis. Principles and methods of sensory evaluation of fresh and processed vegetables.

Practical: Study of machinery and equipments used in processing of horticultural produce; Chemical analysis for nutritive value of fresh and processed vegetables; Study of different types of spoilages in fresh as well as processed horticultural produce; Classification and identification of spoilage organisms; Study of biochemical changes and enzymes associated with spoilage; Laboratory examination of vegetable products; Sensory evaluation of fresh and processed vegetables; Study of food standards – National, international, CODEX Alimentarius; Visit to processing units, to study the layout, equipments, hygiene, sanitation and residual / waste management.

Suggested References

Arthey D & Dennis C. 1996. Vegetable Processing. Blackie/SpringerVerlag.

Chadha DS. 2006. The Prevention of Food Adulteration Act. Confed. of Indian Industry.

FAO. 1997. Fruit and Vegetable Processing. FAO.

FAO. CODEX Alimentarius: Joint FAO/WHO Food Standards Programme. 2nd Ed. Vol. VB. Tropical Fresh Fruits and Vegetables. FAO.

Fellow's P. 1988. Food Processing Technology. Ellis Horwood International. Frazier WC & Westhoff DC. 1995. Food Microbiology. 4th Ed. Tata McGraw Hill.

Giridharilal GS, Siddappa & Tandon GL. 1986. Preservation of Fruits and Vegetables. ICAR.

VSC 514 SYSTEMATICS OF VEGETABLE CROPS 1+1)

Theory

UNIT I :Principles of classification; different methods of classification; salient features of international code of nomenclature of vegetable crops. UNIT II : Origin, history, evolution and distribution of vegetable crops, botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables.

UNIT III: Cytological level of various vegetable crops; descriptive keys for important vegetables.

UNIT IV: Importance of molecular markers in evolution of vegetable crops; molecular markers as an aid in characterization and taxonomy of vegetable crops.

Practical

Identification, description, classification and maintenance of vegetable species and varieties; survey, collection of allied species and general locally available; preparation of keys to the species and varieties; methods of preparation of herbarium and specimens.

Suggested Reference:

Chopra GL. 1968. *Angiosperms - Systematics and Life Cycle*. S. Nagin

Dutta AC. 1986. *A Class Book of Botany*. Oxford Univ. Press.

Pandey BP. 1999. *Taxonomy of Angiosperm*. S. Chand & Co.

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

Soule J. 1985. *Glossary for Horticultural Crops*. John Wiley & Sons.

Srivastava U, Mahajan RK, Gangopadyay KK, Singh M & Dhillon BS. 2001. *Minimal Descriptors of Agri-Horticultural Crops*. Part-II: *Vegetable Crops*. NBPGR, New Delhi.

Vasistha. 1998. *Taxonomy of Angiosperm*. Kalyani.

Vincent ER & Yamaguchi M. 1997. *World Vegetables*. 2nd Ed. Chapman & Hall.

VSC 515 PRODUCTION TECHNOLOGY OF UNDEREXPLOITED VEGETABLE CROPS (1+1)

Theory:

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/ planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operation, weed control, mulching, physiological disorders, harvesting, yield, post harvest management, plant protection measures and seed production of:

UNIT I :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 and little gourd (kundru) and milky mushroom.

Practical : Method of preparation of compost, vermicomposting, biofertilizers, soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, water management, organic soil amendments for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Reference:

Bhat KL. 2001. *Minor Vegetables - Untapped Potential*. Kalyani.

Indira P & Peter KV. 1984. *Unexploited Tropical Vegetables*. Kerala Agricultural University, Kerala.

Peter KV. (Ed.). 2007-08. *Underutilized and Underexploited Horticultural Crops*. Vols. I-IV. New India Publ. Agency.

Rubatzky VE & Yamaguchi M. (Eds.). 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall

Srivastava U, Mahajan RK, Gangopadyay KK, Singh M & Dhillon BS.2001. *Minimal Descriptors of Agri-Horticultural Crops*. Part-II: *Vegetable Crops*. NBPGR, New Delhi.

FLORICULTURE AND LANDSCAPE GARDENING

Code	Course Title	Credits
	A. Core courses	
FLA 501	Breeding of Flower crops and Ornamental Plants	2+1
FLA 502	Production technologies of cut flowers	2+1
FLA 503	Production Technologies for Traditional flowers	2+1
FLA 504	Landscaping and Ornamental Gardening	2+1
FLA 505	Protected cultivation in floriculture	1+1
FLA 506	CAD for outdoor and indoorscaping	1+1
	Total	**16**
	B. Optional courses (Minimum 4 Credits)	
FLA. 507	Nursery management and Commercial floriculture	2+1
FLA .508	Turfing and turf management	1+1
FLA. 509	Value addition in flowers	1+1
FLA. 510	Growth regulators in floriculture	1+1
FLA. 511	Bulbous Ornamentals plants	1+1
FLA. 512	Minor flower crops	1+1
FLA. 513	Indoor gardening, Bonsai and Flower arrangements	1+1
FLA. 514	Weed management in flowers and ornamental crops	1+1
FLA. 515	Seed production of flower crops	1+1
FLA 516	Bio Systematic in Ornamental plants	0+2
	Total	**21**

A. CORE COURSES

FLA 501 BREEDING OF FLOWER CROPS AND ORNAMENTAL PLANTS (2+1)

Theory : Principles – Evolution of varieties, origin, distribution, genetic resources, genetic divergence- Patents and Plant Variety Protection in India.

Genetic inheritance – of flower colour, doubleness, flower size, fragrance, post harvest life.

Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants – introduction, selection, domestication, polyploid and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops.

Breeding constraints and achievements made in commercial flowers – rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster.etc

Breeding constraints and achievements made in ornamental plants – petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snap dragon, pansy) and ornamental foliages – Introduction and selection of plants for waterscaping and xeriscaping.

Practical : Description of botanical features – Cataloguing of cultivars, varieties and species in flowers, floral biology, selfing and crossing, evaluation of hybrid progenies, seed production-Induction of mutants through physical and chemical mutagens, induction of polyploidy, screening of plants for biotic, abiotic stresses and environmental pollution, *in vitro* breeding in flower crops and ornamental plants.

References

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

2. Pal, B.P., 1991. The Rose in India.S.K. Bhattacharjee and L.C. De, 2003. Advanced Commercial Floriculture

3. Bhatta Charjee, S.K., and L.C.De,

4. L.C. De, and Bhatta Charjee, S.K., 2011, Ornamental Crop Breeding

FLA 502 PRODUCTION TECHNOLOGY OF CUT FLOWERS (2+1)

Objective : Importance and production technology of cut flowers grown in India

Theory : Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India- Patent rights, nursery management, media for nursery, special nursery practices.

Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO_2 on growth and flowering.

Flower production – water and nutrient management, fertigation, weed management, ratooning, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purpose.

Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation.

Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Pre-cooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, Agri Export Zones.

Crops: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, liliums, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, gyposphilla, limonium, stock, cut foliages and fillers.

Practical : Botanical description of varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, cold chain, project preparation for regionally important cut flowers, visit to commercial cut flower units and case study.

References

1. Bose, T.K., and Yadav,L.P., 1989. Commercial Flowers.
2. Prasad, S., and Kumar, U., 1998. Commercial Floriculture.
3. Bose, T.K., Yadav,L.P., Pal, P., Das, P., and Parthasarathy.V.A. , Commercial flowers, 2002: Vol. 1 & Vol.2

FLA 503 **PRODUCTION TECHNOLOGY OF TRADITIONAL FLOWERS** **(2+1)**

Theory : Scope of traditional flower trade, Significance in the domestic market/export, Varietal wealth and diversity, propagation, sexual and asexual propagation in mist chambers, nursery management, pro-try nursery under shade nets, transplanting techniques.

Soil and climate requirements, field preparation, systems of planting, precision farming techniques.

Water and nutrient management, weed management, rationing, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM.

Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation.

Harvest indices, harvesting techniques, post harvest handling and grading, packing and storage, value addition, concrete and essential oil extraction, transportation and marketing, export potential, institutional support, Agri Export Zones.

Crops: Jasmine, scented rose, chrysanthmum, marigold, tuberose, crossandra, nerium, hibiscus, barleria, celosia, gaillardia, gomphrena, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, lilies,dahlia,gaillardia, tecoma, champaka, pandanus).

Practical

Botanical description of species and varieties, propagation techniques, mist chamber operation, training and pruning techniques, practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking, harvesting techniques, post-harvest handling, storage and cold chain, project preparation for regionally important commercial loose flowers, visits to fields, essential oil extraction units and markets.

References

1. Bose, T.K., and Yadav, L .P., 1989. Commercial Flowers.

2. Roy A Larson, 1992. Introduction to Floriculture.

3. Surendra Prasad and Updesh Kumar, 1998. Commercial floriculture

4. Bose, T.K., Yadav, L.P., Pal,P., Das, P., and Parthasarathy V.A., Commercial flowers, 2002: Vol. 1 & Vol. 2

FLA 504 LANDSCAPING AND ORNAMENTAL GARDENING (2+1)

Theory : Landscape designs, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, Vanams, Buddha garden; Styles of garden, formal, Informal and free style gardens.

Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporates.

Garden plant components, arboreium, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Production technology for selected ornamental plants.

Lawns, Establishment and maintenance, special types of gardens, vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, couour wheels, temple garden, sacred groves.

Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

Practical : Selection of ornamental plants, practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning, practices in planning and planting of special types of gardens, burlapping, lawn making, planting herbaceous and shrubbery borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

References

1. Bose, T.K., Mukherjee,D., 1977.Gardening in India

2. Randhawa, G.S. and Mukhopadhyaya, A., 1986. Floriculture in India

3. Arora, J.S., 1998.Introductory ornamental Horticulture

4. Swaroop, U., 1997, Ornamental Horticulture

FLA 505 PROTECTED CULTIVATION IN FLORICULTURE (1+1)

Theory : Prospects of protected floriculture in India; Types of protected structures –Greenhouse, polyhouses, shade houses, rain shelters etc., Designing and Erection of protected structures; Low cost/Medium cost/ High cost Structures – economics of cultivation; Location specific designs; Structural Components; Suitable flower crops for protected cultivation.

Environment control – management and manipulation of temperature, light, humidity, air and CO_2; Heating and cooling systems, ventilation, naturally Ventilated greenhouse, fan and pad cooled greenhouses, light regulation.

Containers and substrates, soil decontamination, layout of drip and Fertigation system, water and nutrient management, weed management, Physiological disorders, IPM and IDM.

Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.

Harvest indices, harvesting techniques, post –harvest handling techniques, recooling,sorting, grading, packing storages, quality standards.

Practical :

Study of various protected structures, practices in design, layout and erection of different types of structures, practices in preparatory operations, soil decontamination techniques, practices in environmental control systems, practices, in drip and fertigation techniques, special horticultural practices, determination of harvest indices and harvesting methods, post-harvest handling, packing methods, project preparation, visit to commercial greenhouses.

References

1. Tiwari, G.N.,and R.K. Goyal. 1998.Greenhouse Technology
2. Bose & Yadav, 1989. Commercial Flowers
3. Prasad, S. and V. Kumar. 2001.Green house management for Horticultural crops
4. Prasad, S., Kumar,U., 1998. Commercial Floriculture
5. Bose, T.K., Yadav,L.P., Pal, P., Das, P., and Parthasarathy, V.A., Commercial Flowers, 2002: Vol. 1 & Vol. 2

FLA 506 CAD FOR OUTDOOR AND INDOORSCAPING (1+1)

Theory : Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by Autocad, 3D drawing by CHICAD, 3D drawing by 3D MAX software, creating legends for plant and non-plant components, Basics of Photoshop software in garden designing. 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007,

Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects.

Using patterns in AUTOCAD drawing, drawing, Dimension concepts, Hyperlinking

Script making, Using productivity tools, e-transmit file, making sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout.

3D drawing Methods, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD.

ARCHICAD organization tools, Dimensioning and detailing of designs, Attribute settings of components, Visualization tools for landscape preview, Data management, plotting and accessories for designing, Inserting picture using photoshop, Making sample drawing for outdoor and indoor gardens.

Practical : Practices in point picking methods, Using tool bars and icons, Using modifying tools and modifying comments, Isometric drawings, Using productivity tools, Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden, Using tools and info-box for 3D drawing, Creation of garden components with ARCHICAD, Organization, dimensioning, detailing and visualization tools with ARCHIVAD, Using Photoshop package for 3D picture insertion, Drawing designs with ARCHICAD for home garden, interior garden designing, IT parks, Corporates, Theme parks and Ecotourism spots.

References

1. Farin Gerald E., Josef Hoschek and Myung-Soo Kim, 2002. Handbook of computer aided geometric design.

2. Ambrosius Lee and David Byrnes, 2006. AutoCAD &AutoCAD LT® a l l-I n-*o n e d e s k r e f e r e n c e* : FOR DUMmIES.

3. David Frey and Jon McFarland, 2008. AUTOCAD® 2008 ANDAUTOCAD LT® 2008.

OPTIONAL COURSES

FLA507 NURSERY MANAGEMENT AND COMMERCIAL FLORICULTURE (2+1)

Theory : Introduction, life cycles in plants, cellular basis for propagation, sexual propagation, apomixes, polyembryony, chimeras. Principle factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth.

Seed quality, packing, storage, certification, testing, Asexual propagation-rooting of soft and hard wood cutting under mist by growth regulators. Rooting of cuttings in hotbeds. Physiological, anatomical and biochemeial aspects of root induction in cuttings. Layering – principle and methods. Budding and grafting – selection of elite mother plants, Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility. Rejuvenation through top working – Progeny orchard and scion bank.

Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques – *in vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture. Hardening, packing and transport of micro-propagules.

Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production.

Practical : Anatomical studies in rooting of cutting and graft union, construction of propagation structures, study of media and PGR, micropropagation, explant preparation, media preparation, culturing – *in vitro* clonal propagation, meristem culture, shoot tip culture, axillary bud culture, direct organogenesis, direct and indirect embryogenesis, micro grafting, hardening. Visit to TC labs and nurseries.

References

1. Bose, T.K., and Yadav,P., 1989. Commercial Flowers

2. Prasad, S., and Kumar,U., 1998. Commercial floriculture

3. Grewa, H.S. l, 1999.Propagation of Ornamental Plants

FLA 508 TURFING AND TURF MANAGEMENT (1+1)

Theory : Prospects of landscape industry; History of landscape gardening, site selection, basis requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment.

Turf grasses – Types, species, varieties, hybrids; Selection of grasses for different locations; Grouping according to climatic requirement – Adaptation; Turfing for roof gardens.

Preparatory operations; Growing media used for turf grasses – Turf establishment methods, seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding, astro-turfing.

Turf management – Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing – mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs.

Establishment and maintenance of turfs for play grounds, viz. golf, football, hockey, cricket, tennis, rugby, *etc.*

Practical : Identification of turf grasses, Preparatory operations in turf making, Practices in turf establishment, Layout of macro and Micro irrigation systems, Water and nutrient management; Special practices – mowing, raking, rolling, soil top dressing, weed management; Biotic and abiotic stress management; Project preparation for turf establishment, visit to IT parks, model cricket and golf grounds, airports, corporates, Govt. organizations; Renovation of lawns; Turf economics.

References

1. John H. Madison, 1971.Practical turf grass management
2. Anner, Leslie, 1989. Hand book of Integrated Pest management for turf and ornamentals.
3. Vargas, J.M, 1994. Management of Turf grass Diseases-II Edn.

FLA 509 VALUE ADDITION IN FLOWERS (1+1)

Theory : Prospects of value addition, National and global scenario, production and Exports, Women empowerment through value added products making, Supply chain management.

Types of value added products, value addition in traditional flowers, garlands, veni, floats, floral decorations, value addition in cut flowers, flower arrangement, styles, Ikebana, morebana, free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, etc.; Selection of containers and accessories for floral products and decorations.

Dry flowers – Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower

making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, buttion holes, greeting cards, wreaths; Packing and storage.

Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packing and storage, Selection of species and varieties, Types of pigments, carotenoids, anythocyanin, chlorophyll, betalains; Significance of natural pigments, Extraction methods, Applications.

Practices in preparation of bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers; Techniques in flower arrangement; Techniques in floral decoration; Identification of plants for dry flower making; Practices in dry flower making; Preparation of dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths, *etc.;* Visit to dry flower units, concrete and essential oil extraction units.

References

1. Salunkhe, D.K., Bhatt, and Desai. B,B.,.1990. Post-harvest Biotechnology of Flowers and Ornamental plants
2. S.K. Bhattacharjee, and L.C. De.2005. Post-harvest technology of Flowers and Ornamental Plants
3. Bose, T.K., & Yadav,P., 1989. Commercial flowers
4. Prasad,S., and Kumar, U., 1998. Commercial Floriculture

FLA 510 GROWTH REGULATORS IN FLORICULTURE (1+1)

Theory : Introduction, classification of growth regulators. Synthetic and naturally occurring growth substances. Biosynthesis, metabolism, physiological role and mode of action of different growth regulators and their role with respect to dormancy, promotion and retardation of growth, regulation of flowering, senescence and vase life of flowers.

Practicals : Studies on growth with special reference to growth substances. Laying out of experiments by using different growth regulators on dormancy, apical dominance, rooting of cuttings, growth, flowering, senescence and abscission.

References

1. Bose, T.K., and Yadav,P., 1989. Commercial Flowers
2. Prasad, S., and Kumar, U., 1998. Commercial floriculture

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

4. Richard N. Arteca, 1997. Plant growth substances

FLA 511 BULBOUS ORNAMENTAL PLANTS (1+1)

Theory : Introduction and importance and scope for ornamental bulbous crops. Cultivation of bulbous crops for cut flowers, pot plants and bedding plants. Requirements of temperature, photoperiod and moisture for growth and flowering of important species, agro technique, plant protection, post harvest management.

Practicals : Identification of different species / varieties / types. Techniques of cultivation and handling of bulbs, cut flowers and pot plants.

References

1. Bose & Yadav, 1989. Commercial flowers

2. Surendra Prasad Updesh Kumar, 1998. Commercial floriculture

3. Das, S.N. 2004.Growing Bulbous ornamental plants

FLA 512 MINOR FLOWER CROPS (1+1)

Theory : Importance, history, origin, area and distribution, botany, propagation, crop improvement, varieties, production and cultivation, pests and diseases and post harvest technology of minor commercial flowers like Daisy, Bulbous crops-spider lily, calla lily, tiger lily, foot ball lily, Daffodil, narcissus, zinnia, gaillardia, solidago, calendula, and other seasonals etc.

Practicals : Identifications, classification and description of commercial spices and varieties. Studies on propagation. Layout of experiments to prolong the vase life of cut flowers. Harvesting, grading, storing and packing of flowers. Use of growth regulators. Survey of cut flower markets.

Visit to commercial flower gardens research centres and flower markets and auction centres.

References

1. Bose, T.K., and Yadav, P., 1989. Commercial Flowers

2. Prasad, S., and Kumar,U., 1998. Commercial Floriculture

3. Bob gibbons and Peter Brough, 1982.Wild flowers

FLA 513 INDOOR GARDENING, BONSAI AND FLOWER ARRANGEMENTS (1+1)

Theory : Importance and scope for indoor gardening, plants suitable for indoor gardening, culture and management of indoor plants, environment for indoor plants, light, cooling, humidity and ventilation. Growing media, watering, manuring. Display of indoor plants, furnishing indoor gardens, use of drift wood in indoor gardening, use of hydroculture,hanging plants for indoor gardening , flower arrangements - Introduction, history, importance and scope. Principles of flower arranging, different styles, containers, design for home and special occasions. Flower drying techniques and dry flower arrangements and hand made flowers etc.

Introduction to Bonsai, principles of bonsai, styles of bonsai, techniques in bonsai, containers, media, plants, cultivation and maintenance of bonsai.

Practical : Identification of indoor plants, study of light, heat and water requirements of indoor plants. Diseases and disorders of indoor plants. propagation and use of hydroculture and drift wood in indoors.

Preparation of indoor plants for display; screening of indoor plants for hydro-culture; Bonsai preparations Containers, different materials used in flower arrangements, demonstration of different styles of flower arrangement terrarium, flower drying techniques and dry flower arrangement, hand made flowers.

References

1. Dey, S.C. 2001. Complete Home Gardening
2. Malcolin Hillier, 1995.Container gardening
3. Philip Care, 1996.Creating Japanese gardening
4. Peter chan, 1989.BONSAI

FLA. 514 WEED MANAGEMENT IN FLOWERS AND ORNAMENTAL CROPS (1+1)

Theory : Weeds: Introduction, harmful and beneficial effects, classification, propagation and dissemination; Concepts of weed prevention, control and eradication; Methods of weed control: physical, cultural, chemical and biological methods. Integrated weed management; Herbicides: advantages and limitation of herbicide usage in India, Herbicide classification, formulations, methods of application; Introduction to adjuvants and their use in herbicides; Introduction to selectivity of herbicides; Compatibility of

herbicides with other agro chemicals; Weed management in major flowers and ornamental crops, shift of weed flora in cropping systems, aquatic and problematic weeds and their control.

Practical : Identification of weeds; Survey of weeds in crop fields and other habitats; Preparation of herbarium of weeds; Calculations on weed control efficiency and weed index; Herbicide label information; Computation of herbicide doses; Study of herbicide application equipment and calibration; Demonstration of methods of herbicide application; Preparation of list of commonly available herbicides; Study of phytotoxicity symptoms of herbicides in different crops; Biology of nut sedge, bermuda grass, parthenium and celosia; Economics of weed control practices; Tours and visits of problem areas.

Crops: Rose, gladiolus, gerbera, chrysanthemum, marigold, China aster, tuberose, bird of paradise, dahlia, golden rod, anthurium, lawn and other ornamentals.

References

1. Bose, T.K., and Yadav,P., 1989. Commercial Flowers

2. Prasad,S., Kumar,U., 1998. Commercial Floriculture

FLA 515 SEED PRODUCTION IN FLOWER CROPS (1+1)

Theory : Definition of seed and its quality, new seed policies; DUS test, scope of flower seed industry in India.

Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in flower seed production; floral biology, pollination, breeding behaviour, seed development and maturation; methods of hybrid seed production.

Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control.

Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/ packets), storage and cryopreservation of seeds, synthetic seed technology.

Practical : Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, physical purity) and seed health testing; testing, releasing and notification procedures of varieties; floral biology; rouging of off-type; methods of hybrid seed production in important flower crops, seed extraction

techniques; handling of seed processing and seed testing equipments; seed sampling; testing of flower seeds for seed purity, germination, vigour and health; visit to seed processing units, seed testing laboratory and seed production farms.

References

1. Bose T.K., and Yadav, P., 1989. Commercial flowers

2. Prasad, S., and Kumar, U., 1998. Commercial Floriculture

FLA 516 BIO SYSTEMATICS OF ORNAMENTAL PLANTS (0+2)

Practical : Principles of classification; different methods of classification; salient features of international code of nomenclature of ornamental plants. Origin, history, evolution and distribution of ornamental plants, botanical description of families, genera and species covering various ornamental plant groups.

Identification, description, classification and maintenance of ornamental plants species and varieties; survey, collection of allied species; preparation of keys to the species and varieties; methods of preparation of herbarium and specimens.

Plants groups: Trees, shrubs, climbers, indoor plants, cacti and succulents, palms and cycads, Ferns and Sellagenella, Bulbous plants, Grasses *etc.*.

References

1. Chowali Kameswara Rao, 2004. Flora A to K & L to Z

2. Alfred Byrd Grab, 1985. Exotica Vol. 2

3. Anthony Hurley, 1992. Dictionary of Gardening Vol. 1 to 4

PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

Sl.No	Code	Course Title	Credit
		A. Core Courses (16 credits)	
1.	PMA 501	Production technology of plantation crops(Palms, cashew and rubber)	2+1
2.	PMA 502	Production technology of beverage crops	1+1
3.	PMA 503	Production technology of major spice crops	2+1
4.	PMA 504	Production technology of medicinal crops	2+1
5.	PMA 505	Production technology of aromatic crops	2+1
6.	PMA 506	Breeding of plantation, spices, medicinal and aromatic crops	1+1
		Total	**16**
		B. Optional Courses (Minimum 4 Credits)	
1.	PMA 507	Production technology of minor spice crops	1+1
2.	PMA 508	Organic production of spices, plantation, medicinal and aromatic crops	1+1
3.	PMA 509	Bio-diversity of medicinal, aromatic and natural dye plants	1+1
4.	PMA 510	Processing and quality analysis of medicinal and dye plants	1+1
5.	PMA 511	Natural dye and bio-pesticidal plants	1+1
6.	PMA 512	Production technology of under-utilized spices, medicinal and aromatic Crops	1+1
7.	PMA 513	Propagation of spices, plantation, medicinal and aromatic crops	2+1
8.	PMA 514	Biotechnology of spices, plantation, medicinal and aromatic crops	1+1

9.	PMA 515	Water management of spices, plantation, medicinal and aromatic crops	1+1
10	PMA 516	Nutrition of spices, plantation, medicinal and aromatic crops	1+1
11.	PMA 517	Weed management of spices, plantation, medicinal and aromatic crops	1+1
12.	PMA 518	Value addition, by-product utilization in spices, plantation, medicinal and aromatic crops	1+1
13.	PMA 519	Cropping systems in spices, plantation, medicinal and aromatic crops	1+1
14.	PMA 520	Extraction, storage and quality analysis of essential oils	1+1
		Total	**29**

A. CORE COURSES

PMA 501 PRODUCTION TECHNOLOGY OF PLANTATION CROPS (PALMS, CASHEW AND RUBBER) (2+1)

Theory : Detailed study regarding origin, history, distribution, economic importance, taxonomy, classification, varieties, climatic and soil requirements, propagation and nursery techniques, selection of superior planting material, seed selection, maintenance of seed gardens, methods of planting, cultural practices, nutrition and water requirements, plant protection and management, crop physiology, factors affecting flowering fruit set and yield, harvesting, post-harvest handling, processing, chemical constituents and quality evaluation of coconut, arecanut, oil palm,palmyrah, cashew and rubber. Issues related to intellectual property rights (IPRs), patenting, benefit sharing in utilization of plantation crops.

Specifications required for export of coconut, cashew and other plantation crops.

Practical : Studies on botanical characteristics, propagation and nursery techniques including tissue culture and biotechnology, layout and planting, nutrition and cultural aspects, processing of plant products. Visit to plantation crop research centres and processing centres. Studies on export specification of coconut, arecanut, cashew, palms and rubber.

Suggested References

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

Chopra V.L .,& Peter, K.V. 2005. *Handbook of Industrial Crops*. Panima.

Kurian A & Peter K.V. 2007. *Commercial Crops Technology*. New India Publ. Agency.

Nair M.K, Bhaskara Rao E.V.V, Nambiar K.K.N & Nambiar M.C. 1979. *Cashew*. CPCRI, Kasaragod.

Peter K.V. 2002. *Plantation Crops*. National Book Trust.

Pradeep Kumar T, Suma B, Jyothibhaskar & Satheesan K.N. 2008. *Management of Horticultural Crops*. Part I, II. New India Publ. Agency.

Rai P.S & Vidyachandram B. 1981. *Review of Work Done on Cashew*. UAS, Research Series No.6, Bangalore.

Srivastava H.C, Vatsaya B & Menon K.K.G. 1986. *Plantation Crops – Opportunities and Constraints*. Oxford & IBH.

Thampan P.K. 1981. *Hand Book of Coconut Palm*. Oxford & IBH. 67

Parthasarathy, V.A., Chattopadhyaya, P.K. and Bose T.K. 2006. Plantation crops vol I Naya Udyog Publ.

PMA 502 PRODUCTION TECHNOLOGY OF BEVERAGE CROPS (1+1)

Theory : Origin, history, distribution, economic importance, taxonomy, classification, varieties, climatic and soil requirements, propagation and nursery techniques, cultural practices, nutrition, water requirements, training and pruning systems, regulation of shade, plant protection and management, crop physiology, chemical constituents, post-harvest handling and processing of products, grading, packing, marketing, evaluation of beverage quality of tea, coffee and cocoa.

Practical : Studies on botanical characteristics of varieties, propagation and nursery techniques, growth analysis, layout and planting, nutrition and cultural aspects, processing of plant products, identification of field problems and their analysis. Visit to plantations and Research Institutes.

Suggested References

Harler C.R. 1963. *The Culture and Marketing of Tea*. Oxford Univ. Press.

Kurian A & Peter K.V. 2007. *Commercial Crops Technology*. New India Publ. Agency.

Peter K.V. 2002. *Plantation Crops*. National Book Trust.

Ranganathan V. 1979. *Hand Book of Tea Cultivation*. UPASI, Tea Res. Stn. Cinchona.

Eden, T., "*Tea" (*Longman) – Tropical Agric.Series,

Misra, Rajan, S., 1986, *Tea industry in India.* Ashis Publishing House, 8/18, Punjabi Bagh, New Delhi – 110 026. 158P.

Harler, C.R., " *Tea Growing"* (Oxford University Press)

UPASI, KVK, Conoor – Guidelines on tea culture in South India.

Petch, T., "*The Disease of the Tea Bush"* Mc Million & Co. Ltd

Haarer, A. E., "Modern Coffee Production"

CCRI , " *Coffee Planters Guide*" Central Coffee Research Institute, Balehonnur

CCRI., 1997, " *Coffee Guide*" Central Coffee Research Institute, Coffee Research Station, Balehonnur- 577 117, Chikkmagalore District. 180 P

Wickizer, V.D., "*Coffee, Tea, and Cocoa"*

CTA, 1992, *Cocoa – The Tropical Agriculturist Series,* Ed Coste, R., The Technical Centre for Agricultural and Rural Co-operation.

Cocoa Cultivation – Science and Technique - By Coconut Development Board, Ministry of Agriculture, Government of India, Kera Bhavan, Kochi – 682 011

PMA 503 PRODUCTION TECHNOLOGY OF MAJOR SPICE CROPS (2+1)

Theory : Introduction, importance of spice crops-historical accent, present status - national and international, future prospects, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, site selection, layout, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed planting material and micro-propagation, precision farming, organic resource management, organic certification, quality control, pharmaceutical significance and protected cultivation of: Black pepper, cardamom, Clove, cinnamon , nutmeg, allspice, Turmeric, ginger garlic, Tamarind and vanilla

Practical : Identification of seeds and plants, botanical description of plant; preparation of herbarium, propagation, nursery raising, field layout and method of planting, cultural practices, harvesting, drying, storage, packaging and processing, value addition; short term experiments on spice crops.

Suggested References

Agarwal S, Sastry E.V.D & Sharma R.K. 2001. *Seed Spices: Production, Quality, Export*. Pointer Publ. Arya PS. 2003. *Spice Crops of India*. Kalyani.

Bhattacharjee S.K. 2000. *Hand Book of Aromatic Plants*. Pointer Publ.

Bose TK, Mitra SK, Farooqi S.K & Sadhu MK (Eds.). 1999. *Tropical Horticulture*. Vol.I. Naya Prokash.

Chadha K.L & Rethinam P. (Eds.). 1993. *Advances in Horticulture*. Vols. IX-X. *Plantation Crops and Spices*. Malhotra Publ. House.

Kumar N.A, Khader P, Rangaswami & Irulappan I. 2000. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Oxford & IBH.

Nybe E.V, Miniraj N & Peter K.V. 2007. *Spices*. New India Publ. Agency. Parthasarthy V.A, Kandiannan V & Srinivasan V. 2008. *Organic Spices*. New India Publ. Agency.

Peter K.V. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ. Co. UK and CRC USA 68

Pruthi J.S. (Ed.). 1998. *Spices and Condiments*. National Book Trust

Pruthi J.S. 2001. *Minor Spices and Condiments- Crop Management and Post Harvest Technology*. ICAR.

Purseglove J.W, Brown E.G, Green C.L & Robbins SRJ. (Eds.). 1981. *Spices*. Vols. I, II. Longman.

Shanmugavelu K.G, Kumar N & Peter K.V. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.

Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.

Tiwari R.S & Agarwal A. 2004. *Production Technology of Spices*. International Book Distr. Co.

Varmudy V. 2001. *Marketing of Spices*. Daya Publ. House.

PMA 504 PRODUCTION TECHNOLOGY OF MEDICINAL CROPS (2+1)

Theory : Introduction, historical background, importance, present status and future prospects. Chemistry of active ingredients and classification of drugs. Problems of production and marketing. Origin, distribution, species varieties, economic parts and their uses in different climatic and soil requirements, propagation and nursery techniques, planting and after care, nutrition, weed and water management. Use of growth regulators, plant protection and harvesting of commercial medicinal crops of south India and Karnataka, such as Medicinal yams (*Dioscorea sp.*), Sarpagandha, Periwinkle, Safed Musli, Stevia, Tropical soda apple (*Solanum viarum*), Costus, Opium Poppy, Senna, Ashwagandha, Cinchona, Guggul, Glory lily, Medicinal Coleus, Isabgol, Pyrethrum, Long pepper, Aloevera, Cowhage, Honey plant.

Practical : Studies on botanical characteristics of species and varieties of different commercial medicinal crops. Study of economic parts and their products. Propagation and nursery techniques. Study of pests and diseases and their management. Visit to the organizations and plantations of different medicinal crops.

Suggested references

1. Atal, C.K. and Kapur B.M. Cultivation and Utilization of medicinal plants. R.R.L., CSIR, Jammu.
2. Chadha K.L and Gupta R. Advances in Horticulture, Volume. XI. Malhotra Publication House.

3. Handa S.S and Kaul M.K. Supplement to Cultivation and Utilization of medicinal plants R.R.L., Jammu.

4. Kurian A. and Asha Sankar M. Medicinal Plants, Horticulture Series–2 New India Publication Agency.

5. Prajapati N.D., Purohit S. S., Sharma, A. K. and Kumar T. A. Hand Book of Medicinal Plants. Agro Bios.

6. Jain S.K, Medicinal Plants. National Book Trust.

PMA 505 PRODUCTION TECHNOLOGY OF AROMATIC CROPS (2+1)

Theory : Introduction, historical background, importance, present status and future prospects of aromatic crops. Chemistry of aromatic compounds, production methods and uses of essential oils. Problems of production and marketing of different aromatic crops. Origin, distribution, species varieties, economic parts and their uses of different essential oils. Climatic and soil requirements, propagation and nursery techniques, planting and after care, nutrition, weed and water management. Use of phyto hormones, plant protection and harvesting of commercial aromatic crops of south India and Karnataka such as French Jasmine, tuberose, Basils, Davana, Sandalwood, Bursera, Ambrette, Patchouli, Scented Rose, Rosemary, Aromatic grasses, Scented geranium, Mints, Lemon scented gum, Marjoram, Fennel, Celery, Thyme, Dill, *etc*.

Practicals : Studies on botanical characteristics of species and varieties of different commercial aromatic crops. Study of economic parts and their essential oils. Propagation and nursery techniques. Study of pests and diseases and their management. Visit to the research institutes and plantations of different aromatic crops.

Suggested references

1. Akhtar Husain. Essential plants and their cultivation. CIMAP, Lucknow.

2. Bhattacharjee S.K. Hand Book of Aromatic plants. Pointer Publication.

3. Peter K.V. Aromatic Plants. Horticulture Series. New India Publication Agency.

4. Atal C.K. and Kapur B.M. Cultivation and Utilization of Aromatic plants. RRL, Jammu.

5. Handa S.S and Kaul M.K.1997,Suplement to cultivation and utilization of aromatic plants, RRL Jammu.

6. Chadha K.L. and Gupta R. Advances in Horticulture. Vol. XI. Malhotra Publication House.

PMA 506 BREEDING OF PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS (1+1)

Theory : Species and cultivars, cytogenetics, survey, collection, conservation and evaluation, blossom biology, breeding objectives, approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploid breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses. Scope for improvement of Medicinal and Aromatic crops through selection, intra and interspecific hybridization, induced autotetraploidy and mutation breeding. Genetics of active principles and assay techniques useful in evaluation of breeder's material. Problems in promotion of improved types in seed and vegetatively propagated types. Achievements and prospects in breeding of medicinal and aromatic crops.

Practical: Comparative study of species, genera, and families for floral morphology and seed production in the context of breeding behaviour. Methods of selfing and crossing, detection of out crossing, pollen assay techniques, study of genetic variability in exhomorphic/yield characters in varietal collection, induction and evaluation of autotetraploids. Study of mutategens, induction of mutation and evaluation of mutants. Chemical assay of active constituents in some important medicinal and aromatic crops for genetic variation.

Crops

Plantation and spices : Coffee, tea, cashew, cocoa, rubber, palmyrah, oil palm, coconut, areca nut, black pepper, cardamom, ginger, turmeric, nutmeg, cinnamon, clove and allspice

Medicinal and aromatic crops : Medicinal yams, steroid-bearing Solanums, opium poppy, belladonna, periwinkle, Foxglove, Isabgol, Senna, Pyrethrum, Medicinal Coleus, Ashwagandha, Sarpagandha, French jasmine, scented geranium, mints, aromatic grasses, Basils, patchouli, rosemary, davana, dill, fennel

Practical : Characterization and evaluation of germplasm accessions, Blossom biology, studies on pollen behaviour, practices in hybridization, ploidy breeding,

mutation breeding, evaluation of biometrical traits and quality traits, screening for biotic and abiotic stresses, haploid culture, protoplast culture and fusion-induction of somaclonal variation and screening the variants. Identification and familiarization of spices; floral biology anthesis; fruit set; selfing and crossing techniques; description of varieties. Salient features of improved varieties and cultivars from public and private sector, bioinformatics, visit to radiotracer laboratory, national institutes for plantation crops and plant genetic resource centers, genetic transformation in plantation crops for resistance to biotic stress/quality improvement etc.

Suggested Readings

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

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

Chadha K.L, Ravindran P.N & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops.* Malhotra Publ. House.

Chadha K.L. 1998. *Advances in Horticulture*. Vol. IX. *Plantation and Spices Crops*. Malhotra Publishing House, New Delhi.

Ferwerden F.P & Wit F. (Ed.). 1969. *Outlines of Perennial Crop Breeding in the Tropics*. H. Veenman & Zonen.

Harver A.E. 1962. *Modern Coffee Production*. Leonard Hoff.

Chadha K.L & Gupta R. 1995. *Advances in Horticulture*. Vol. XI. Malhotra Publ. House.

Farooqi A.A, Khan M.M & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops.* Natural Remedies Pvt. Ltd.

Jain S.K. 2000. *Medicinal Plants*. National Book Trust.

Julia F & Charters M.C. 1997. *Major Medicinal Plants – Botany, Cultures and Uses*. Thomas Publ.

Kurian A & Asha Sankar, M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

Prajapati N.D, Paero Hit S.S, Sharma A.K, Kumar T. 2006. *A Hand book of Medicinal Plants*. Agro Bios (India).

Skaria P Babu. 2007. *Aromatic Plants*. New India Publ. Agency.

Thakur R.S, Pauri H.S & Hussain A. 1989. *Major Medicinal Plants of India*. CSIR.

OPTIONAL COURSES

PMA 507 PRODUCTION TECHNOLOGY OF MINOR SPICE CROPS (1+1)

Theory : Importance and scope of Betelvine, kokam, tamarind, curryleaf, sweet flag, etc. special features of these crops. Varieties, climatic and soil requirements, propagation and nursery techniques, cultural practices, nutrition, water requirements, training and pruning systems, regulation of shade in betelvine garden. Crop protection and management, chemical constituents. Post harvest handling and processing of products, grading, packing, marketing. Detailed study regarding origin, history, distribution, economic importance, taxonomy, classification, varieties, climatic requirements, propagation and nursery techniques, cultural practices, nutritional and water requirements, plant protection and management, crop physiology, crop improvement, chemical constituents, post-harvest handling and processing of plant products of spice crops like coriander, mustard, fenugreek, fennel, garlic, onions, methi, jeera, celery, dill, cumin, caraway, chilli, paprika, bishop weed.

Practical : Studies on characteristics of varieties, propagation and nursery techniques, growth analysis, layout and planting, nutrition and cultural aspects, processing of plant products. Identification of field problems and their analysis. Visit to various, betelvine, kokam and tamarind plantations and research stations. Studies on botanical characteristics of varieties or cultivars and plant types, propagation and nursery techniques, field layout and methods of planting. Foliar diagnostic techniques for nutritional requirements. Harvesting and processing of plant products of important spices and condiments. Visit to important Research Central Plantations.

Suggested References

Marsh A.C, Moss M.K & Murphy E.W. 1977. *Composition of Food Spices and Herbs, Raw, Processed and Prepared*. Agric. Res. Serv. Hand Book 8-2. Washinton DC.

Peter K.V. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ. Co., UK & CRC, USA.

Purseglove J.W, Brown E.G, Green C.L & Robbins SRJ. 1984. *Spices.* Vols. I, II. Longman.

Ridley H.M. 1972. *Spices*. Mac Millan.

Rosengarten F Jr. 1969. *The Book of Spices*. Wynnewood; Livingston Publ. Co.

Agarwal S, Divkara Sastry E.V & Sharma R.K. 2001. Seed Spices, Production, Quality and Export. Pointer Publ.

Nybe E.V, Mini Raj N & Peter K.V. 2007. *Spices*. New India Publ. Agency.

Varmudy V. 2001. *Marketing of Spices*. Daya Publ. House.

PMA 508 ORGANIC PRODUCTION SPICES, PLANTATION, MEDICINAL AND AROMATIC CROPS (1+1)

Theory

* Importance, principles, perspective, concept and component of organic production of spice and plantation crops.
* Organic production of spice crops and plantation crops *viz.* Black pepper, cardamom, turmeric, ginger, cumin, fenugreek, coriander, vanilla, coconut, coffee, cocoa, tea, areca nut.
* Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.
* Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, panchagavya, biodynamics, preparation *etc.* Pest and disease management in organic farming; ITK's in organic farming . Role of botanicals and bio-control agents.
* GAP and GMP – certification of organic products ; organic production and export- opportunity and challenges.

Practical : Method of preparation of compost, vermicomposting, biofertilizers, soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, water management, organic soil amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested References

Dahama A.K. 2005. *Organic Farming for Sustainable Agriculture*. 2nd Ed. Agrobios.

Gehlot G. 2005. *Organic Farming: Standards, Accreditation, Certification and Inspection*. Agrobios.

Palaniappan S.P & Annadorai K. 2003. *Organic Farming: Theory and Practice*. Scientific Publ.

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

Shivashankar K. 1997. *Food Security in Harmony with Nature*. 3rd IFOAMASIA, Scientific Conference. 1-4 Dec., 1997, UAS, Bangalore

PMA 509 BIO-DIVERSITY OF MEDICINAL, AROMATIC AND (1+1)
NATURAL DYE PLANTS

Theory : Geographic distribution of MADPs (medicinal, aromatic and natural dye plants) and genetic 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 germ plasm collection -planning and logistics-plant exploration and exchange-plant quarantine principles, regulations plant quarantine systems in India. Components of germplasm evaluation, descriptor lists. Some practical considerations of germplasm evaluation -conservation of MADPs genetics 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 from natural sources and preparation of herbarium. Botanical, phyto-chemical and galanicals groupings of medicinal and aromatic plants. Classification of M & APs 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.

Suggested references

1. R.C. Rajak. and M. K. Rai. Herbal Medicines, Biodiversity and Conservation strategies.IBH.
2. Trivedi P.C. Medicinal Plants: Utilization and Conservation.
3. Negi S.S. Biodiversity of India and its Conservation.
4. Choudhari, A.B. Megadiversity Conservation: Flora, Fauna and Medicinal Plants of India’s hot spots.

5. Atal C.K. and Kapur B.M. Cultivation and Utilization and Medicinal Plants. R.R.L., Jammu.
6. Atal C.K. and Kapur B.M. Cultivation and Utilization of Aromatic Plants. R.R.L., Jammu.
7. Sushil Kumar, Janardhan Singh, Shah N.C. and Vijay Ranjan. Indian Medicinal and Aromatic Plants Facing Genetic Erosion. CIMAP. Lucknow.
8. The Wealth of India (Raw Materials). CSIR.

PMA 510 PROCESSING AND QUALITY ANALYSIS (1+1)

OF MEDICINAL AND DYE PLANTS

Theory : History and development of different extraction methods of active principles of commercial medicinal crops. Handling and processing of different plant materials before extraction. Preparation of plant material for extraction. Study of different methods of extraction of alkaloids, diterpenes and other compounds from different economic parts. Study of preparation of different end products of medicinal plants. Study of different physical and chemical methods in quality analysis active chemical compounds. Role of instrumentation in quality analysis. Principles and practices of different types of chromatograms: paper, thin layer, column, gas-liquid and high performance liquid chromatograph (HPLC). Industrial commercial uses of plant extracts.

Practicals : Identification of different economic parts and commercial produce. Preparation of plant material for extraction. Study of different extraction methods for plant extracts, like water extraction, solvent extraction, drying and purification. Use of soxhlet method for isolation of extract. Extraction of crude drugs from different medicinal crops. Determination of extractable matter, water and volatile matter, bitterness value, tannins, swelling index in isabgol husk and seeds, etc. Handling of chromatographs, quality analysis of purified compounds for adulteration and other forging matter. Storage studies in essential oils. Visit to commercial extraction and product development units.

Suggested references

1. Atal C.K. and Kapur B.M. Cultivation and Utilization of Medicinal Plants. R.R.L, Jammu.
2. Mukherjee B.M. Standardization of Botanical, Testing and Methods of Extraction of Medicinal Herbs. Volume-1 and 2. Eastern Publication.
3. Chatwal and Anand, S. Instrumental Methods and Chemicals Analysis. Himalaya Publications.

4. Anonymous Quality Control methods for Medicinal Plants Material. W.H.O publication

PMA 511 NATURAL DYE AND BIO-PESTICIDAL PLANTS (1+1)

Theory : Introduction, historical background, present status and different uses of edible dyes and bio-pesticidal plants. Origin and distribution, species varieties, economic parts. Soil and climatic requirements, nutrition, water and weed management. Plant protection, harvesting and extraction of active principles in different dye yielding and bio-pesticidal plants like Annatto, Mehandi, Indigo, Indian Maddar, Marigold, *Caesalpinia sappan*, Pyrethrum, Red sanders, Neem, Sweet flag, Adhatoda, *Clerodendron inerme*, *Vitex nigondu*, etc. The chemistry, bioefficacy, toxicity of different bio-pesticidal plants.

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

Suggested references

1. Parkes C. H; 'Creating colour in Yarn: An introduction to natural Dyes', Knitter's Review, 2002-2003.
2. http://www.housebarra.com/EP/ep03/03dyes.html; 'Natural dyes', December 22, 2003.
3. www.pioneerthinking.com; 'Making Natural Dyes from Plants', June 25, 2003.
4. The Wealth of India, Raw Materials, CSIR, 17, 8, 1990
5. Green, C. L., 1995. "Natural Colorants and Dyestuffs", Food and Agriculture Organization of the United Nations, Italy
6. Lewin, M. and S. Sello, 1983, "Handbook of Fiber Science and Technology: Chemical Processing of Fiber and Fabrics", Marcel Dekker, NY,

PMA 512 PRODUCTION TECHNOLOGY OF UNDER UTILIZED SPICES, MEDICINAL AND AROMATIC CROPS (1+1)

Theory : Introduction, importance, present status and future prospects. Origin, distribution, species varieties, economic parts and their uses in different diseases, climatic and soil requirements, propagation and nursery techniques, planting and after care, weed and water management. Plant protection and

harvesting of *Myristica malabarica,* mango ginger, kodampuli, monkey jack, *Xanthoxylum limonella, Flocourtia montana*, Indian borage (*Coleus aromaticus*), *Cassia tamala*, perennial coriander (*Erangium foetida*), carombola, etc medicinal and aromatic plants, such as Sweet flag, vasaka, Antamul, Geloe, madunashini, Babchi, vayuvidanga, Brangaraja, Chakramani, Hibiscus, Aristalochia, *Morinda citrifolia, Caesalpinia sappan*, *Caralluma, Terminalia chebula, Strychnos nuxvomica, Solanum trilobatum,* Physalis, *Aegle marmelos, Alpinia* sp., *Anthocephalus kadamba, Costus. Chitramoola, Bursera,* marjorum, annapurna, kacholum,*etc.*

Practical : Studies on botanical characteristics of species and varieties of different underexploited Medicinal and Aromatic Plants. Study of economic parts and their products. Propagation and nursery techniques. Study of pests and diseases and their management. Visit to the organizations and herbal gardens.

Suggested References

1. Peter K.V. Under exploited and under utilized Horticulture crops. Volume I–IV. New India Publication Agency.
2. Atal C.K. and Kapur B.M. Cultivation and Utilization of Medicinal Plants. R.R.L, Jammu.
3. Atal C.K and Kapur B.M. Cultivation and Utilization of Aromatic Plants. R.R.L, Jammu.
4. Chadha K.L. and Gupta R. Advances in Horticulture. Volume-XI. Malhotra Publication House.
5. CSIR, The Wealth of India. Volume A-Z CSIR

PMA 513 PROPAGATION OF SPICES, PLANTATION, MEDICINAL AND AROMATIC CROPS (2+1)

Theory : Introduction, life cycles in plants, cellular basis for propagation, sexual propagation, apomixes, polyembryony, chimeras. Principle factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth. Seed quality, packing, storage, certification, testing, Asexual propagation-rooting of soft and hard wood cutting under mist by growth regulators. Rooting of cuttings in hotbeds. Physiological, anatomical and biochemeial aspects of root induction in cuttings. Layering – principle and methods. Budding and grafting – selection of elite mother plants, Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility. Rejuventation through top working – Progeny orchard and

scion bank. Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques – *in vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture. Hardening, packing and transport of micro-propagules. Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production.

Practical : Anatomical studies in rooting of cutting and graft union, construction of propagation structures, study of media and PGR, case studies, micropropagation, explant preparation, media preparation, culturing – *in vitro* clonal propagation, meristem culture, shoot tip culture, axillary bud culture, direct organogenesis, direct and indirect embryogenesis, micro grafting, hardening. Visit to TC labs and nurseries.

Suggested references

1. Hartmann, Kester, D.E. and F.T. Davies, 1993. Plant Propagation-principles and practices. Prentice Hall international inc.
2. Parthasarathy, V.A., Utpala Parthasarathy and A.Kumar, 2008. Spices Vol 2, Todays and Tomarrows publishers
3. Kurien, A and K.V.Peter, 2007. Commercial crops technology. New India Publishing Agency.
4. Bhojwani, S.S.(Eds), 1990. Plant tissue culture. Elsevier science pub

PMA514 BIOTECHNOLOGY OF SPICES, PLANTATION, MEDICINAL AND AROMATIC CROPS (1+1)

Theory : Harnessing bio-technology in horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture. Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis. Use of bioreactors and *in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues a nd cells, regeneration of tissues, *ex vitro,* establishment of tissue cultured plants. Physiology of hardening – hardening and field transfer, organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture and fusion. Construction and identification of somatic hybrids and cybrids, wide hybridization, in vitro pollination and fertilization, haploids, *in vitro* mutation, artificial seeds, cryopreservation, rapid clonal propagation, genetic engineering in horticulture crops, use of molecular markers. In vitro selection for biotic and abiotic stress, achievements of biotechonolgy in horticultural crops.

Practical : An exposure to low cost, commercial and homestead tissue culture laboratories, media preparation, inoculation of explants for clonal propagation, callus induction and culture, regeneration of platnt-lets from callus, sub-culturing, techniques on anther, ovule, embryo culture, somaclonal variation, *in vitro* mutant selection against abiotic stress, protoplast culture, fusion technique, development of protocols for mass multiplication, project development of commercial tissue culture laboratory.

Suggested references

1. Singh, B.D., 2007. Biotechnology.
2. Parthasarathy, V.A., Utpala Parthasarathy and A.Kumar, 2008. Spices Vol 2, Todays and Tomarrows publishers
3. Bhojwani, S.S.(Eds), 1990. Plant tissue culture. Elsevier science pub
4. Parthasarathy, V.A, Bose, T.K, Deka, P.C, Das, P, Mitra S.K and Mohandas, S. 2001. Biotechnology of Horicultural crops New India publ agency.
5. Chadha K.L, Ravindran, P.N, and Sahijram, L. (Eds). 2000. Biotechnology of Horticulture and Plantation crops. Malhotra publ. House

PMA 515 WATER MANAGEMENT OF SPICES, PLANTATION, MEDICINAL AND AROMATIC CROPS (1+1)

Theory : Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states. Problelms of irrigated agriculture in India and Karnataka. Soil water movement in soil and plants; transpiration; soil-water-plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation ,micro irrigation, system; fertigation; management of water in controlled environments and polyhouses. Methods to determine water requirement of crops. Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; water use efficiency. Excess of soil water and plant growth, water management in problem soils; Drainage requirement of crops and methods of field drainage, their layout and spacing. Principles and practices of drainage**.**

Practical : Measurement of soil water potential by using tensiometer and pressure, plate and membrane apparatus, Study of sprinkler irrigation system.

Soil-moisture characteristics curves, Study of drip irrigation system, water flow measurements using different devices, Working out of crop W.R. Determination of irrigation requirements. Study on farm development structures. Calculation of irrigation efficiency.

Suggested references

1. Rao, Y.P., and S.R.Bhaskar, 2008. Irrigation technology theory. Agrotech publishing academy.

2. Sankara Reddi, G.H., and T. Yellamanda Reddy, 1999. Efficient use of irrigation water. Kalyani publishers.

PMA516 NUTRITION OF SPICES, PLANTATION, MEDICINAL AND AROMATIC CROPS 1+1

Theory : Historical background, criteria of essentiality of nutrient elements, classification of plant nutrients and their role. Symptoms of deficiency and toxicity – their corrective measures. Nutritional disorders. Interrelationships of elements. Nutrient uptake and translocation, factors affecting nutrient availability. Leaf sampling techniques, nutrient diagnostic techniques (DRIS), index tissue and nutrient standards. Manures and fertilizers – their composition and availability of essential nutrients. Nutritional requirements of perennial and seasonal horticultural crops. Time, Sources and methods of nutrient application. Bio-fertilizers – classification, vermicuture and vermicomposting. Integrated nutrient management. Effects of nutrient elements on growth, yield and quality. Mineral nutrition in relation to problematic soils. Organic farming, Fertigation, slow release fertilizers.

Practical : Field identification of deficiencies and toxic symptoms. Nutrient culture studies. Leaf sampling techniques and analysis for nutrient status. Soil and foliar application of fertilizers preparation of nutrient solution, compatibility of different fertilizers and pesticides.

Suggested references

1. Marschner, H., 1995. Mineral nutrition of higher plants. Academic press.

2. Kurien, A and K.V.Peter, 2007. Commercial crops technology. New India Publishing Agency

3. Tisdale, S.L., WL Nelson, JD Becton and JL Havlin, 1995. Soil fertility and fertilisers. Prentice-Hall Internatl Inc.

PMA 517 WEED MANAGEMENT OF SPICES, PLANTATION, MEDICINAL AND AROMATIC CROPS (1+1)

Theory : Weed biology and ecology; Crop-weed competition including allelopathy; Weed indices - Classification and characteristics of weeds; Principles and methods of weed control: prevention, physical, mechanical, cultural, biological including bio-herbicides, allelochemicals and chemical weed control. Herbicides-introduction and history of their development, Classification based on chemical, physiological application and selectivity; Mode and mechanism of action of herbicides Herbicide structure – activity relationship; Factors affecting the efficiency of herbicides; Herbicide formulations, herbicide mixtures; Herbicide resistance and management; Weed control through bio-herbicides; Myco-herbicides and allele-chemicals; Degradation of herbicides in soil and plants; Herbicide resistance in weeds and crops. Herbicide rotation. Weed management in major crops and cropping systems; Parasitic weeds; Weed Shifts in cropping systems; Aquatic and perennial weed control, integrated weed management; Cost-benefit analysis of weed management.

Practical : Identification of important weeds of different crops, preparation of a weed herbarium, weed survey in crops and cropping system, crop-weed competition studies, preparation of spray solutions of herbicides for high and low volume sprayers, use of various types of spray pumps and nozzles and calculation of swath width, economics of weed control. Herbicides resistance analysis in plants and soil, Bioassay of herbicide resistance, calculation of herbicidal requirement.

Suggested references

1. Shanmugavelu, K.G., and R. Aravindan.2008. Weed management in Horticultural crops. Agribios publ.
2. Gupta,O.P., 2000. Modern weed management. Agrobios.
3. Rao, V. S., 2004. Principles of weed science. Oxford publishers.
4. Ghonsikar, C.P., and V.S. Shinde, 1997. Nutrient management practices in crops and cropping systems
5. Chadha, K.L., D.Leela and Prabha Challa, 1997. Weed management in horticulture and plantation crops. Malhotra publishing house New Delhi

PMA518 VALUE ADDITION, BY-PRODUCT UTILIZATION IN SPICES, PLANTATION, MEDICINAL AND AROMATIC CROPS (1+1)

Thoery : Commercial uses of spices and plantation crops. Introduction to processing and products in plantation and spice crops. Significance of on farm processing and quality of finished products. Processing of major spices, - Extraction of oleoresin and essential oils. Processing of produce from plantation and spice crops. Byproduct utilization in plantation crops for coir production, mushroom culture, cocopit, bee keeping, toddy tapping, Oil cake production and utilization, vermi-composting, Fuel wood and timber wood from perennial spices and plantation crops (crops, *viz*. coconut, areca nut, cashew nut, oil palm, palmyrah, date palm, cocoa, tea, coffee, rubber *etc*. cardamom, black pepper, ginger, turmeric, chilli and paprika, vanilla, cinnamon, clove, nutmeg, allspice, coriander, fenugreek, curry leaf, *etc*). Value addition on aromatic oils and medicinal herbs. Utilization of spent material of medicinal and aromatic crops in manufacture of agarabatti, organic manures and other useful products. Detoxification of waste materials. Role of spent material in bio-control of diseases and pest in organic farming. Role of micro-organisms in conversion of waste in to useful products. Objectives of waste utilization, method of safe disposal of waste material, improvement of soil fertility, improvement of soil tilth and reduction of soil erosion.

Practical : Study on product diversification in plantation and spice crops. (e.g. Coconut : fresh nuts, tender nuts, coconut milk, cream, spray dried coconut milk powder, defatted coconut powder, desiccated coconut, virgin coconut oil, preserved tender coconut water, toddy utilization in jaggary, alcohol, sugar, vinegar etc, coconut based dairy products- chips, biscuits, Nata-de-coes, coconut shell products, coir and its utilization *etc*)Study of processing and by product utilization of different spices and plantation, medicinal and aromatic crops. Methods of byproduct utilization in plantation crops for coir production, mushroom culture, coco-pit, honey bee keeping, Oil cake production and utilization, vermi-composting *etc*, Study of processing of medicinal plants, their drying and storage. Extraction and identification of active ingredients from different spices and herbs using TLC, HPLC, GC/CG-MS technology. Study of waste material utilization in aromatic crops such as davana, lemon grass, vetiver, palmarosa, patchouli, rosemary, java citronella, etc. Usage of spent material in agarbatti manufacturing, Value added products from spices and plantation crops.

Suggested references

1. Chadha KL et al(Eds) 1993-95. Advances in Horticulture. Vol IX. Plantation crops and spices. Malhotra publishing house, New Delhi.
2. Peter, K.V.(Ed). 2001. Handbook of Herbs and spices. Vol I-III. Wood Head publ co. UK &CRC, USA
3. Mandal, RC, 1996. Coconut production and Processing technology. Agro. Bot.
4. Mandal, RC, 1997. Cashew: Production and processing technology. Agro Bot.

PMA 519 CROPPING SYSTEMS IN SPICES, PLANTATION, MEDICINAL AND AROMATIC CROPS (1+1)

System approach in the cultivation of spices, plantation, medicinal and aromatic crops. Definition and importance of natural and physical resources in the cultivation of crops and their management in spices, plantation, medicinal and aromatic crops based cropping system. Multiple cropping, intercropping, sequential cropping, alley cropping, mixed cropping, multistoried cropping, in spices, plantation, medicinal and aromatic crop based cropping system. Advantages, interactions and associated constraints , complimentary interactions – competitions – allelopathic effect, role of non monetary inputs and low cost technologies – input use efficiency, land use indices including Crop intensity index (CII) and Land Equivalent Ration (LER) in different of spices, plantation, medicinal and aromatic crop based cropping systems. Assessment of viability of a cropping system, yield advantage, economic evaluation of cropping systems- Important plantation and spice based cropping systems prevailing in South India including areca nut and coconut based multi-storied systems. Medicinal and aromatic crops based cropping systems.

Mixed farming – Integrated farming systems (IFS), - choice of enterprises interaction among enterprises- advantages of different IFS models for different situation for spices, plantation, medicinal and aromatic crop based integrated farming system.

Practical Study on the efficiency of utilization of natural resources (soil/ land and solar radiation) under different plantation based spice gardens and cropping systems. Studies on the management of nutrition and water under different plantation/ spices/medicinal/aromatic crop based cropping systems. Studies on integrated management of pest and diseases under different plantation/ spices/medicinal/aromatic crop based cropping systems.

Suggested References

Dwivedi, A.P. 1992, Agroforestry Principles and practices Oxford & IBH

Gangopadhyaya, A., 2007, Crop Production systems and Management. Gene Tech Books

Palaniyappan, S.P. and Sivaraman, K. 1996, Cropping systems in the tropics : Principles and Management, New Age Publishers

Panda, S.C., 2003, Cropping and Farming systems, Agrobios

Sen,N. L., Dadheech, R.C. Dashora, L.K. and Rawat, T.S. 2004 Manual of Agroforestry and Social Forestry, Agrotech Publ.

PMA 520 EXTRACTION, STORAGE AND QUALITY ANALYSIS OF ESSENTIAL OILS (1+1)

Theory : History and development of different extraction methods. Handling and processing of different plant materials before extraction. Preparation of plant material for packaging and extraction. Principles and practices of different methods of essential oil extraction- distillation, solvent extraction, maceration, enfleurage, expression method and super critical fluid extraction (SCFE), etc. Study of preparation of different end products of aromatic plants. Study of different physical and chemical methods in quality analysis of essential oils. Role of instrumentation in quality analysis. Principles and practices of different types of chromatograms: paper, thin layer, column, gas, gas-liquid. Storage of essential oils. Principles of sensory evaluation of essential oils. Industrial uses of essential oils. Study of adulterating materials and their identification.

Practicals :Identification of different economic parts. Preparation of plant material for extraction. Study of different extraction methods for essential oils *viz.* hydro and steam distillation, solvent extraction and SCFE methods. Extraction of crude drugs from different medicinal crops. Handling of chromatographs, quality analysis of essential oils through physico-chemical methods. Determination of density, refractive index, specific gravity, optical rotation, polarity, acid value, phenol value, alcohol value, ester value, etc and sensory evaluation of essential oils. Storage studies in essential oils. Visit to commercial extraction and product development units.

Suggested References

1. Guenther E. The essential oils. Volume 1-6.

2. Atal C.K. and Kapur B.M. Cultivation and Utilization of Medicinal Plants, R.R.L, Jammu

3. Mahendra, Extraction methods.

4. Chatwal and Anand S. Instrumental methods and chemical analysis. Himalaya Publication.

5. Varshney S.C. Mint essential oils by distillation.

POST HARVEST TECHNOLOGY

Sl. No.	Course number	Course Title	Credit hours
A.		**Core courses** (16 credits)	
1.	PHT 501	Post-harvest physiology and management of horticultural produce	2+1
2.	PHT 502	Storage and packaging technology for fresh and processed horticultural produce	2+1
3.	PHT 503	Principles and methods of fruit and vegetable processing	2+1
4.	PHT 504	Preservation by fermentation and dehydration	1+1
5.	PHT 505	Food Additives in Horticultural Products	1+1
6.	PHT 506	Techniques for quality control and sensory analysis of horticultural products	2+1
		Total	**16**
		B. Optional courses (Minimum 4 Credits))	
7.	PHT 507	Preservation by canning and freezing	1+1
8.	PHT 508	Processing technology for spices and plantation crops	1+1
9.	PHT 509	Post harvest handling and processing of ornamental, medicinal and aromatic plants	1+1
10.	PHT 510	*In-plant* training and management of waste from horticultural processing industries	1+1
11.	PHT 511	Process engineering in horticultural crops	1+1
12.	PHT 512	Safety in horticulture food chain	2+0
		Total	**12**

A. CORE COURSE

PHT 501 POST-HARVEST PHYSIOLOGY AND MANAGEMENT OF HORTICULTURAL PRODUCE (2+1)

Theory: Importance of post-harvest handling of horticultural produce. Pre and post-harvest losses and their causes. Nature and structure of fruits, vegetables and flowers. Maturity indices for harvest of important horticulture crops. Physico-chemical changes during development, ripening and storage. Impact of physiological processes - respiration, transpiration, ethylene evolution on ripening and senescence. Biosynthesis of ethylene. Recommended ripening conditions for different fruits. Sources of ethylene for ripening. Climacteric and non-climacteric fruits. Regulation of ripening by use of chemicals and growth regulators. Control of dormancy, sprouting and discolouration in vegetables.

Harvesting, harvesting tools and their design aspects; curing, washing, sorting, grading of fruits, flowers and vegetables for local markets and export. Pre-treatments for extending vase life of cut flowers. Post-harvest handling of spices, plantation crops, medicinal and aromatic plants. Equipments for washing, sizing, grading. Prepackage operations - pre-cooling, methods and requirements for fruits, vegetables and flowers. Pre and post-harvest treatments for extending storage life. Prepackaging, VHT and irradiation treatment of fruit/vegetable/spices. Packaging techniques for local market and export. Standards and specifications for fresh produce. Post Harvest handling of horticulture crops of regional importance.

Transportation and supply chain management of horticulture produce. Marketing - factors influencing marketing of perishable crops, marketing systems and organisations.

Practicals : Studies on morphological features of some selected fruits and vegetables; Study of maturity indices for harvest of fruits, vegetables, spices and plantation crops. Determination of physiological loss in weight and respiration rate in fruits and vegetables. Determination of RQ. Determination of chemical constituents like sugar, starch, pigments, vitamin C, carotenes, acidity during maturation and ripening in fruits/vegetables. Estimation of ethylene evolved from ripening fruits. Hastening of ripening by ethrel treatments. Protective skin coating with wax emulsion and pre and post-harvest treatment with fungicides, chemicals and growth regulators to extend the shelf life of fruits and vegetables. Prepackaging, and VHT. Extension of vaselife of cut flowers by use of chemicals and growth regulators. Control of

sprouting of potato and onion by using growth regulators. Study of modernharvesting, sorting and grading equipments. Study of effect of pre-cooling on shelf-life and quality of fresh fruits, vegetables and flowers. Study of packages - bulk and consumer packs for different fruits, vegetables, flowers and spices. Visit to packaging centres. Visit to local markets, cooperative organisations like HOPCOMS, SAFAL, super markets dealing with marketing of perishables.

Suggested References

Bhattachajee SK and Dee LC. 2005. *Post harvest technology of flowers and ornamental plants.* Pointer publishers, Jaipur.

Chattopadhyay SK 2007. *Handiling, transportation and storage of fruit and vegetables.* Gene- Tech books, New Delhi.

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Postharvest Physiology and Pathology of Vegetables edited by Jerry A. Bartz, Jeffrey K. Brecht CRC Press.

Pruthi JS 2001 (Reprint). Major spices of india crop management and *Post harvest technology.* ICAR, New Delhi

Pruthi JS. 1976. Spices and condiments. National Book Trust

Salunkhe DK, Bolia HR and Reddy NR. 1991. *Storage, Processing & Nutritional Quality of Fruit and Vegetables.* Vol.I, *Fruit and Vegetables* CRC

Saraswathy S Preeti JL, Balasubramanyan S, Suresh J, Revathy N and Natarajan S 2008. *Post harvest management of horticultural crops.* AGRIBIOS (India).

Singh DK & Singh SK. 2005. *Physiology and post harvest management of horticulktural crops. Agrotech publishing Academy Udaipur.*

Siris Mitra. 2005. Post harvest physiology and storage of tropical and subtropical fruits. CABI Publishing.

Stawley J. Kays. 1998. Post harvest physiology of perishable plant products. CBS publishers.

Sudheer KP and Indira V 2007. *Post harvest technology for horticultural crops.* New India publishing Agency.

Thompson AK, 1995. *Post harvest technology of Fruit and Vegetables* Blackwell Sci,

Verma LR and VR Josh LR 2000 *Post harvest technology Fruit and Vegetables vol-1.* Indus publishing company.

Weichmann J.1987, *Post harvest physiology of vegetables.* New York and Basel.

Wills RBH Mc Glasson WB Graham D 2007. *Post harvest An introduction to physiology and handling of fruits, vegetables and ornamentals. University of new south Wales Press,*

PHT 502 STORAGE AND PACKAGING TECHNOLOGY FOR FRESH AND PROCESSED HORTICULTURAL PRODUCE (2+1)

Theory: Importance of storage of horticultural produce, present status and future scope.

Principles and methods of storage – field storage structures and designs for bulk storage of vegetables like onion, potato, etc. Evaporative cool chambers. Physiological changes during storage.

Refrigerated storage - principles of refrigeration, types of refrigerants, refrigeration equipments - types of compressors, evaporators, condensers, refrigeration control systems. Defrosting methods. Selection of site. Construction of cold storage room, material required, types of insulation and construction material, designs of cold storage warehouses - modular, intermediate and large cold storage houses. Calculation of refrigeration requirement for a known quantity of fruit/vegetable. Factors affecting storage life of horticultural produce in cold room, temperature requirements of different fruits, vegetables, flowers. Chilling injury - symptoms and methods to reduce it.

Controlled or modified atmosphere (CA/MA) storage - principles, uses, structures and equipments, methods and requirements, effect of CA storage on the physiology of stored produce. Hypobaric storage - principles, uses, methods, structures and equipments and requirements. Storage disorders and spoilages.

Importance of packaging of fresh and processed horticultural produce, present status and future scope. Gaps in packaging concepts. Packaging patterns and methods. Graphic design of packages.

Food packaging systems: Different forms of packaging such as rigid, semi-rigid, flexible forms. Paper based packages: corrugated fibre board boxes - raw material and types of boxes. Metal cans : types, fabrication, lacquering, tin quality - classification and Tetra pack. Double seaming technology - defects and causes. Glass containers - types, classification, testing quality - thermal shock resistance, thermal shock breakage, impact breakage. Flexible packaging materials - types and their properties. Consumer and intermediate flexible bulk containers. Testing of flexible packaging material. Barrier properties of packaging materials. New technology in packaging - stretch wrapping system, vacuum packaging, gas packaging, controlled atmosphere packaging, vibra packaging, skin packaging, shrink packaging, form-fill-seal packaging, aseptic packaging. Packaging requirements of fresh and processed horticultural produce. Determination of shelf-life of packed products. Packaging machines. Quality control and safety aspects of packaging materials.

Practicals : Study of special storage structures for bulk storage of onion, potato, *etc.* Study of construction and working of zero energy cool chamber. Study of storage behavior of different fruits and vegetables in zero energy cool chamber. Study of construction of refrigerated cold storage room. Study of refrigeration system and different types of compressors, evaporators, condensers, defrosting and refrigeration control systems. Determination of refrigeration requirements (capacity) for given quantity of fruits and vegetables. Study of storage behaviour of different fruits and vegetables in cold room. Study of chilling injury and storage disorders. Study of shelf-life of fruits and vegetables in modified atmosphere packaging. Visit to special storage structures, cold storage units.

Study of types of packaging materials, types of plastic films and their properties. Determination of water vapour transmission rate (WVTR) and gas transmission rate (GTR) of packaging material. Applications of packaging material for fresh and processed fruits and vegetables, beverage foods, spice products. Testing the compression strength of the boxes; Packaging the food material in seal and shrink packaging machine and study its shelf life. To perform vacuum packaging of food sample and carry out its storage study. Testing the strength of glass containers by thermal shock test. Testing the strength of filled pouches by drop tester. Determination of shelf-life of packed products in different t ypes of packages. Seam evaluation and study of defects in seams. Study of packaging machines - vacuum packer, double seamer, etc.

Suggested References

Ahvenainen R. 2001. Novel Food Packaging Techniques. CRC.

A.K. Thompson 2010, *Controlled Atmosphere Storage of Fruits and Vegetables, CABI Publishing; 2nd revised edition.*

Chattopadhya SK. 2007. Handling, transportation and storage of fruits and vegetables. Gene-Tech books, New Delhi.

Chandra Gopala Rao 2015. Engineering for Storage of Fruits and Vegetables; Academic Press, 1st Edition.

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Mahadevaiah M and Gowramma RV. 1996. Food packaging materials. Tata McGraw Hill.

Painy FA. 1992. A handbook of food packaging. Blackie Academic.

Pantastico B. 1975. Post Harvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables. AVI Publ.

Robertson GL. 1992. Food Packaging-Principles and Practices. Marcel Dekker.

Sacharow S and Griffin RC. 1980. Principles of Food Packaging. AVI Publ.

Salunkhe DK & Kadam SS. 1998. Handbook of Vegetables Science & Technology: Production, Composition, Storage and Processing. Marcel Dekker.

Salunkhe DK & Kadam SS. 1995. Handbook of fruit Science & Technology: Production, Composition, Storage and Processing. Marcel Dekker.

Salunkhe DK, Bolia HR & Reddy NR. 1991. Storage, Processing and Nutritional Quality of Fruits and Vegetables. Vol. I. Fruits and Vegetables. CRC.

Sisir Mitra. 2005. Post harvest physiology and storage of tropical and sub tropical fruits. CABI Publishing.

Thompson AK. 1995. Post Harvest Technology of Fruits and Vegetables. Blackwell Sci.

Verma LR. & Joshi VK. 2000. Post Harvest Technology of Fruits and Vegetables. Indus Publ.

PHT 503 PRICNIPLES AND METHODS OF FRUIT AND VEGETABLE PROCESSING (2+1)

Theory : Importance of processing of fruits and vegetables. Indian and global scenario on production and processing of fruits and vegetable; History of food preservation. Present status and future prospects of fruit and vegetable preservation industry in India. Quality requirements of raw materials for processing; sourcing and receiving at processing plants; minimal processing. Nutritive value of processed fruits and vegetables. Role of microorganisms, enzymes and water activity in preservation, Spoilage of fresh and processed horticultural produce. Biochemical changes and enzymes associated with

spoilage of horticultural produce. Principal spoilage organisms, food poisoning and their control measures.

Primary , secondary and tertary processing. Principles and methods of preservation by heat, drying, chemicals, radiation, freezing, fermentation, *etc.* Important fruit and vegetable products. Preservation of fruit juices, beverages, pulp, puree and concentrates. Methods of preparation of confectionery and tomato products. Technology for fruit and vegetable based snacks: Chips, wafers; Processing of fruits for candies, bars, toffees, jams and jellies from locally available fruits.Hurdle technology, non thermal processing,extrusion technology and IQF. Processing equipments and layout of processing industry, plant sanitation. Quality assurance and quality control, TQM, GMP. Food standards – FPO, PFA, FSSA etc. Food laws and regulations. Food safety – HACCP. Nutrition labeling. Utilization of horticulture wastes and by-products. Principles and methods of sensory evaluation of fresh and processed fruits and vegetables.

Practical: Study of tools and equipments used in processing of horticultural produce. Chemical analysis for nutritive value of fresh and processed fruits and vegetables. Preparation and preservation of fruit based beverages and blended products from fruits and vegetables. Evaluation of pectin grade; preparation and quality evaluation of fruit jam. Preparation of papain. Preparation of dehydrated vegetables. Study of different types of spoilages in fresh as well as processed horticultural produce. Classification and identification of spoilage organisms. Study of biochemical changes and enzymes associated with spoilage. Laboratory examination of fruit and vegetable products. Sensory evaluation of fresh and processed fruits and vegetables. Visit to CFTRI, Mysore.

Suggested References

Barret DM, Somogyi LP & Ramaswamy H. 2005. Processing of Fruits. CRC Press

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

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Hui VH, Sue Ghazala, Dee M. Graham, Murrel KD and Wai-Kit Nip. 2004. Hand book of vegetable preservation and processing. New York and Basel.

Lal G, Siddappa GS & Tandon GL. 1998. Preservation of Fruits and Vegetables. ICAR.

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Salunkhe DK & Kadam SS.1995. Handbook of Fruit Science & Technology: Production, Composition and Processing. Marcel Dekker.

Salunkhe DK & Kadam SS. 1995. Handbook of Vegetables Science &Technology: Production, Composition, Storage and Processing. Marcel Dekker.

Srivastava RP & Kumar S. 2003. Fruit and Vegetable Preservation-Principles and Practices. International Book Distributors.

PHT 504 PRESERVATION BY FERMENTATION AND DEHYDRATION **(1+1)**

Theory: Importance of preservation of horticultural produce by fermentation and dehydration.

Principles and methods of preservation by fermentation - Alcoholic, Acetic, Lactic. Factors affecting yeast and bacterial fermentation, Study of alcoholic fermentation with special reference to wine. History of wine making, present international and national status of wine production and wine market, scope and importance of wine industries, classification of wines, nutritional and therapeutic value of wine, technology of wine production. Different types of grape wines, production of wine from fruits other than the grapes. Commercial aspect of wine production. Preparation and preservation of other fermented products like vinegar, sauerkraut etc. Packaging technology, labeling and storage of wines and other fermented products.

Principles and techniques of dehydration, pretreatments and methods - sun drying, shade drying and artificial drying, equipments - cabinet drier, tunnel drier, spray drier, fluidized bed drier, freeze drier, vacuum drier, solar drier, *etc.* Commodity requirements, drying rates, moisture levels, enzymes in dehydration processes. Packaging of dried products. Drying techniques for preparation of raisin, dried fig, banana fig, potato chips, peas, onion, mushroom, spices and plantation crops. Osmotic dehydration. Intermediate moisture foods (IMF).

Quality analysis of fermented and dehydrated products. Sanitation and cleaning requirements for winery and dehydration plants. Spoilages in fermented and dehydrated products.

Practicals : Study of equipments used in wine making. Preparation and preservation of grape wines - dry wines, dessert wines, orange wine, other

fruit wines etc. Preparation and preservation of vinegar and sauerkraut. Lactic acid fermentation of non-acid vegetables - cucumber, carrot, *etc.,* as a prerequisite to pickling. Packaging of fermented products. Analysis of physico-chemical and sensory quality of wine and other fermented products.

Study of equipments used in dehydration; Study of pretreatments for dehydration. Preparation of dried/dehydrated products - raisin, banana, fig, potato, peas, onion, pepper, cardamom, mushroom, *etc.* Evaluation of different methods of drying - sun drying, shade drying, artificial drying using electricity. Packaging of dried products.

Analysis of quality of fermented and dehydrated products. Examination of spoilages in fermented and dehydrated products. Visit to processing factories – winery, wine park and dehydration units.

Suggested References

Arsdel WB, Copley MJ and Morgan AI. 1973. Food dehydration. 2nd Ed. Vol I and II. AVI Publication.

Barbosa-Cánovas GV. 2000. Dehydration of Foods. Chapman & Hall.

Brian Mc Neil, Linda Harvey. Practical Fermentation Technology. John Wiley & Sons, Inc.

Hui YH, Clary C, Farid MM, Fasina OO, Noomhorm A and Welti-Chanes A. 2008. Food drying science and technology-microbiology, chemistry, applications. DE Stech Publications, Inc.

Lal G, Siddappa GS and Tandon GL. 1998. Preservation of Fruits and Vegetables. ICAR.

Loesecke. 2004. Drying and Dehydration of foods. AGROBIOS (India).

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Pak Lam Yu, P L Yu, Pak Lam Yu. Fermentation Technologies: Industrial Applications. Springer.

Sandor Elix Katz 2012. The art of Fermentation, Chelsea Green Publishing Co.

Srivastava ML. Fermentation Technology. Narosa.

Srivastava RP & Kumar S. 2003. Fruit and Vegetable Preservation-Principles and Practices. International Book Distributors.

Stanbury PF, Hall S. and Whitaker A. 1998. Principles of Fermentation Technology. Elsevier Publication.

Steinkraus KS. 1996. Handbook of Indigenous Fermented Foods. Marcel Dekker.

Sudheer KP and Indira V. 2007. Post harvest technology for horticulture crops. New India publishing Agency.

Verma LR and V.R. Josh LR. 2000. Post harvest technology of fruits and vegetables handling, processing, fermentation and waste management. Vol-2. Indus Publishing company.

Yiu H. Hui and Y. H. Hui. 2004. Hand book of food and beverage fermentation technology. Marcel Dekker.

PHT 505 FOOD ADDITIVES IN HORTICULTURE PRODUCE (1+1)

Theory: Importance of preservation of horticultural produce by food additives and preservatives. Principles and methods of preservation by use of sugar, salt, spices, essential oils, vinegar and chemical preservatives. Food additives- definitions, classification and functions, Preservatives - mode of action of chemical preservatives; antioxidants, colours and flavours (synthetic and natural), emulsifiers, sequesterants, humectants, hydrocolloids, sweeteners, acidulants, buffering salts, anticaking agents, clarifying agents *etc.* - chemistry, uses in horticulture foods and functions in formulations; indirect food additives; toxicological evaluation of food additives.

Flavour technology: Types of flavours, flavours generated during processing – reaction flavours, flavour composites, stability of flavours during food processing, flavour emulsions; essential oils and oleoresins; authentication of flavours *etc.*

Uses of enzymes in extraction of juices. Pectic substances and their role as jellifying agents. Carbonated and non-carbonated fruit beverages - their preparation and preservation. Proteins, starches and lipids as functional ingredient; functional properties and applications in horticultural foods.

Study of spoilages in preserved products. Safety of food additives.

Practicals : Extraction of fruit and vegetable juices using enzymes. clarification, preservation and storage of juices. Preparation and preservation of RTS, cordial, squash, concentrate and syrup. Preparation and preservation of jam, jelly, marmalade, ketchup, sauce, preserves, chutneys, pickles, candies, crystallized products, gulkand. Use of additives and preservatives in these products.

Preparation and preservation of carbonated beverages. Sensory evaluation and quality analysis of preserved products. Study of spoilages in preserved products. Visit to processing factories.

Suggested References

Branen AL, Oavidson PM and Salminen S. 2001. Food additives, 2nd Ed. revised and expanded edited by A. Larry Branen P. Michael Davidson Seppo Salminen and John H. Thorngate II Marcel Dekker, Inc.

Gerorge AB. 1996. Encyclopedia of Food and Color Additives. Vol. III. CRC Press.

Gerorge AB. 2004. Fenaroli's Handbook of Flavour Ingredients. 5th Ed. CRC Press.

Madhavi DL, Deshpande SS and Salunkhe DK. 1996. Food Antioxidants: Technological, Toxicological and Health Perspective. Marcel Dekker.

Morton ID and Macleod AJ.1990. Food Flavours. Part A, BC. Elsevier.

Methods of analysis of food components and additives edited by Semith Otles published by CRC press Taylor and Francis Group.

Nagodawithana T and Reed G. 1993. Enzymes in food processing. Academic Press.

Nakai S and Modler HW. 2000. Food Proteins-Processing Applications. Wiley VCH.

Nicholas J. Russel and Grahame W. Gould. 2003. Food Preservatives. Springer

Norman W. Desrosier and James N. Desrosier. 1987. The technology of food preservation. CBS publishers and Distribution.

Stephen AM. (Ed.). 2006. Food Polysaccharides and Their Applications. Marcel Dekker.

Udhal Singh Meena and Suresh Kumar P. 2005. Glimpses of post harvest management. New Vishal publ. New Delhi.

Whitehurst R. and Lawry B. 2002. Enzymes in food technology. Blackwell.

PHT 506 TECHNIQUES FOR QUALITY CONTROL AND SENSORY ANALYSIS OF HORTICULRUAL PRODUCTS (2+1)

Theory: Concept of quality: Quality attributes- physical, chemical, nutritional, microbial, and sensory; their measurement and evaluation; instrumental vis-à-vis sensory methods for testing quality. Functions and methods of quality assessment of fruits and vegetable products. Specifications for finished products.Non-destructive quality evaluation-Principles and methods. Sampling techniques. Principles and techniques of analysis of proximate composition of fruit and vegetables and their products. Chemical and physical nature of food additives. Estimation of food additives. Colour evaluation with respect to the value, hue and chroma. Rheological properties -Texture, tenderness and consistency evaluation. Laboratory examinations of canned products

– drained weight, vacuum/pressure, head space, water activity, acidity, pH, vitamins and microbial quality. Interpretation of laboratory analysis in relation to product quality. Statistical quality control. Quality assurance: Total quality management, GMP, HACCP. Sanitary and hygienic practices.

Importance, objecives and methods of sensory analysis; Requirements of sensory evaluation laboratory; Organizing sensory evaluation programme; Panel selection and training. Analysis for appearance, taste, aroma, colour, gloss, texture and flavour. Detection, threshold and dilution tests. Different tests for sensory evaluation– discrimination, descriptive, affective; Flavour profile and tests; Ranking tests; Methods of sensory evaluation of different food products. Designing of experiments. Handling and interpretation of data. Role of sensory evaluation in product optimisation. Relationship between objective and subjective methods. Sensory analysis for consumer evaluation. Computer-aided sensory evaluation of food and beverage.

Practicals :Demonstration of measurement of vacuum/pressure, head space, filled weight, drained weight, cut-out analysis and chemical additives. Analysis for TSS, pH, acidity, sugars, pectic substances, minerals, vitamin C, carotene, alcohol, nitrogen, artificial colouring matter and sweeteners, benzoic acid and SO_2 contents, caffeine, yeast and microbial examination in processed products. Moisture content, rehydration ratio and enzymatic /non-enzymatic browning in dehydrated products. Analysis of spices for determining volatile oil and moisture content. Estimation of piperine in pepper oleoresin, curcumin in turmeric powder, gengerol in ginger oleoresin. Evaluation of typical products according to food laws. HACCP exercise, problem solving techniques, group discussion.

Selection and training of sensory panel. Identification of basic taste, odour, texture and colour. Detection and threshold tests; Ranking tests for taste, aroma, colour and texture; Sensory evaluation of various horticultural processed products using different scales, score cards and tests, Hedonic testing. Estimation of color and texture; Optimising a product by sensory analysis. Studying relationship between objective and subjective methods

Suggested References

Amerine MA, Pangborn RM & Rosslos EB. 1965. Principles of Sensory Evaluation of Food. Academic Press.

Early R.1995. Guide to Quality Management Systems for Food Industries. Blackie Academic.

Furia TE.1980. Regulatory status of Direct Food Additives. CRC Press.

Jellinek G. 1985. Sensory Evaluation of Food-Theory and Practice. Ellis Horwoood.

Krammer A and Twigg BA.1973. Quality Control in Food Industry. Vol. I, II. AVI Publ.

Lawless HT and Klein BP. 1991. Sensory Science theory and application in foods. Marcel Dekker.

Macrae R, Roloson R and Sadlu MJ. 1994. Encyclopedia of Food Science & Technology & Nutrition. Vol. XVI. Academic Press.

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

Piggot JR. 1984. Sensory Evaluation of Foods. Elbview Applied Science.

Rai SC and Bhatia VK. 1988. Sensory evaluation of Agricultural products. IASRI, ICAR.

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

Robinson JW. 1970. Undergraduate Instrumental Analysis. Marcel Dekker.

B.OPTIONAL COURSES

PHT 507 PRESERVATION BY CANNING AND FREEZING (1+1)

Theory: Importance of preservation of horticultural produce by canning and freezing, present status and future scope. Principles and techniques for canning/bottling, containers for canning and bottling - tin and glass containers, open top sanitary cans, technology and fabrication of tin plate, tin coating, lacquering, can seaming technology, equipments for canning and their operation. Unit operations in a canning line. Raw materials for canning/bottling, canning of important fruits/vegetables and their products. Aseptic canning methods, equipments. Processing - determination of processing time and temperature, TDT and TDP, heat penetration studies and calculation of process time. Thermal process evaluation.

Principles, equipments and techniques for freezing preservation of fruits, vegetables and their products - slow freezing, quick freezing. Freezing methods : air freezing, immersion freezing, indirect contact freezing, cryo freezing, dehydrofreezing. Package requirement for frozen products. Transportation of frozen products. Influence of freezing on the quality of frozen products.Microbial safety and quality analysis of canned and frozen products. Spoilages in canned and frozen products.

Practicals : Study of equipments and machineries used in canning and bottling. Study of containers used in canning and bottling - glass containers, open top sanitary cans. Operation of can reforming and seaming machines.

Study of unit operations in canning line. Preparation of canned products - pineapple, orange, mango, sapota, peas, cauliflower, *etc.* Determination of thermal death time curve. Heat penetration studies in canned product. Calculation of process time.

Study of freezing machineries and frozen food storage equipments. Study of effect of slow and quick freezing. Preparation and preservation of frozen fruit and vegetable products. Packaging of frozen products.

Sensory evaluation and quality analysis of canned, bottled and frozen products. Sanitation and cleaning requirements for processing plants. Study of spoilages in canned, bottled and frozen products. Corrosion of cans. Visit to canneries and freezing units.

Suggested References

Cruess WV. 1997. Commercial fruit and vegetable products. Allied Scientific publisher.

Lal G, Siddappa GS & Tandon GL. 1998. Preservation of Fruits and Vegetables. ICAR.

NIIR Board. Hand book on fruits, vegetables: Food processing with canning and preservation. Asia Pacific Business press Inc.

Srivastava RP & Kumar S. 2003. Fruit and Vegetable Preservation-Principles and Practices. International Book Distributors.

Tressler DK, Van Ardel WB and Copley MJ. 1969. The Freezing Preservation of foods. Vol I & II. AVI Publishing Co.

Mallett CP. 1993. Frozen Food Technology. Blackie Academic & Professional.

Yiu H. Hui. 2004. Hand book of frozen foods. Marcel Dekker.

NIIR Board. 2003. The complete book on processing, dehydration, canning preservation of fruits & vegetables. NIIR project consultancy services.

Jean Larousse and Bruce E. Brown. 1997. Food canning technology (Ed.). Wiley- VCH.

Verma LR. & Joshi VK. 2000. Post Harvest Technology of Fruits and Vegetables. Vol. 2. Indus Publ.

Sudheer KP and Indira V. 2007. Post harvest technology for horticulture crops. New India publishing Agency.

PHT 508 PROCESSING TECHNOLOGY FOR SPICES AND PLANTATION CROPS (1+1)

Theory

Coconut : Processing techniques for production of copra, coconut oil, desiccated coconut, coconut milk, cream, syrup, honey, toddy, *etc.* Packaging of tender coconut water. Byproducts of coconut - cake, coconut fibre (coir), coirpith, coconut shell, *etc.* Coir products and byproducts.

Arecanut : Processing techniques for production of Kottaipak (Chali), kalipak, neetadaka, scented supari. Grading and storage. Utilization of byproducts.

Cashewnut : Processing cashew apple and preservation. Cashewnut processing, grading and packing. Byproducts - shell oil (CNSL), testa tannin, etc.

Oil Palm : Processing techniques for extraction of oil from mesocarp and kernel. Refining of crude oil. Quality of oil.

Cocoa : Fermentation and drying of cocoa beans. Preparation of cocoa products - cocoa butter, powder, chocolate, etc. Chemistry of cocoa fermentation.

Coffee : Chemistry of constituents. Processing technology for production of cherry and parchment coffee. Changes taking place during fermentation, drying, roasting; Preparation of coffee powder and instant coffee. Grades of coffee. Chicory chemistry. Aderltarants used in coffee blending. Caffeine and its uses.

Tea : Harvesting time and methods. Techniques of tea manufacturing. Blending and grading. Types of tea. Standards of purity grades. Judging tea quality. Chemistry of tea.

Rubber : Collection and pre-processing of rubber latex. Processing of rubber latex into latex concentrates, sheet rubber, crepe rubber, block rubber, etc.

Vanilla : Curing of vanilla pods and extraction of oil.

Betelvine : Production of bleached leaves.

Tamarind : Processing technology for production of powder and paste.

Kokum (*Garcinia indica*) : Extraction and Preparation of fruit juice concentrate, carbonated and non-carbonated beverage.

Pepper : Processing technology for black pepper, white pepper, dehydrated green pepper, buff coloured pepper and canned green pepper, Extraction of oleoresin. Production of pepper oil.

Cardamom : Techniques of curing cardamom - sun drying, flue curing. Production of green and white cardamom. Extraction of cardamom oil. Processing of large cardamom.

Ginger : Techniques of curing ginger - bleached and unbleached ginger, peeled whole ginger, sliced ginger, split ginger. Extraction of oleoresin and oil.

Turmeric : Techniques of curing turmeric. Extraction of oleoresin and curcumin.

Tree spices : Processing of nutmeg, clove and Cinnamon. Extraction of oil. Garlic : Curing and extraction of oil. Curry leaf : Extraction of oil and production of curry leaf powder. Chillies and paprika : Extraction of oleoresin and pigments.

Grading and packing of processed products of spices and plantation crops. Selection and types of packaging materials. Storage of processed products. Quality of processed products.

Practicals : Preparation of coconut products - copra, desiccated coconut, coconut milk. Packaging of tender coconut water. Extraction of fibre from coconut husk. Preparation of Kalipak from tender arecanuts and scented supari. Processing of cashewnuts, grading and packaging of cashew kernels.

Extraction, fermentation and drying of cocoa beans. Preparation of parchment coffee. Curing of vanilla pods. Bleaching of betelvine leaves. Preparation of tamarind paste and powder. Preparation of black and white pepper, dehydrated green pepper. Extraction of oleoresin and oil from pepper. Curing and drying of cardamom and extraction of oil. Curing of ginger and extraction of oleoresin. Curing of turmeric and extraction of oleoresin. Curing and extraction of oil from garlic. Extraction of curry leaf oil. Extraction of oleoresin from chillies. Detection of microbial quality and adulteration in spices, aromatic compounds in spices; storage and packaging of spices. Visit to spice and plantation crop processing Units.

Suggested Reference:

Banerjee B. 2002. Tea Production and Processing. Oxford Univ. Press.

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

Fellows PJ. 1988. Food Processing Technology. Ellis Horwood International. Switzerland.

Fennema OR. 1985. Food Chemistry. Marcel Dekker.

Kumar N, Abdul Khader ML, Rangaswamy P & Ikrulappan I. 1994. Spices, Plantation Crops, Medicinal and Aromatic Plants. Rajalakshmi Publ.

Dashora LK, Abhay Dashora and Lakhawat SS. 2006. Production Technology of Plantation Crops, Spices, Aromatic and Medicinal Plants. Agrotech.

Mandal RC. 1996. Coconut Production and Processing Technology. Agro. Bot.

Mandal RC. 1997. Cashew: Production and Processing Technology. Agro. Bot.

Minifie BW. 1999. Chocolate, Cocoa and Confectionery Technology. 3rd Ed. Aspen Publ.

NAIR. 2004. Handbook on Spices. National Institute of Industrial Research Board, Asia Pacific Business Press Inc.

Parthasarathy VA, Chempakam B and Zachariah TJ. 2008. Chemistry of spices. CABI

Peter KV. (Ed.). 2001. Handbook of Herbs and Spices. Vols.I-III. Wood Head Publishing Co., UK & CRC, USA.

K.V. Peter., K.P. Sudheer, V. Indira., Post Harvest Technology of Horticultural Crops, Horticulture Science Series 7 Chief editor, new India publishing agency (NIPA)

K.V. Peter., **Plantation Crops by** National Book Trust India, Page no. 84 and 85

Pruthi JS. 2001(Reprint). Major spices of India-Crop management and Postharvest Technology. ICAR, New Delhi.

Pruthi JS. 1976. Spices and condiments. National Book Trust.

Sudheer KP and Indira V. 2008. Post-Harvest Technology of Horticultural Crops. Horticulture Science Series. New India Publ. Agency.

Sivetz M and Foote HE. 1963. Coffee Processing Technology. AVI Publ.

PHT 509 POST HARVEST HANDLING AND PROCESSING OF ORNAMENTAL, MEDICINAL AND AROMATIC PLANTS (1+1)

Theory: Importance and scope. Post harvest physiological and biochemical changes. Maturity indices; harvesting, grading, bunching of cut-flowers; Factors affecting cut-flower longevity; Pretreatments for extending the vase life of cut flowers, precooling, use of preservative solutions, growth

regulators and other chemicals. Preparation of cut-flowers for market and transportation. Export requirement. Dutch auctioning system**.**

Post harvest handling of aromatic and medicinal plants. Recommended storage techniques and condition for ornamentals, medicinal and aromatic plants. Processing of medicinal plants – dioscorea, coleus, ashwagandha, tulsi, isabgol, safed musli, *etc.* Different methods of drying and storage. Influence of temperature and time combination on active principles. Extraction and analysis of active principles. Distillation, solvent extraction from aromatic plants – davana, mint, rosemary, rose, citronella, lavender, jasmine, etc. Identification of different odour factors in essential oil.

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

Maturity indices and harvesting of medicinal and aromatic plants. Study of processing of medicinal plants, their drying and storage. Extraction of essential oils from different aromatic plants. Distillation, solvent extraction from aromatic plants – davana, mint, rosemary, rose, citronella, lavender, jasmine, etc. Physico-chemical and sensory evaluation of oils. Identification of different odour factors in essential oil with GLC. Extraction and analysis of active principles using TLC, HPLC, GC/CG-MS technology.

Value added products from ornamentals, medicinal and aromatic plants. Visit to flower auction centre and essential oil extraction unit.

Suggested Reference:

Atal CK and Kapur BM. 1982. Cultivation and utilization of medicinal plants. RRL., Jammu

Bhattacharjee SK and Dee LC. 2005. Post harvest technology of flowers and ornamental plants. Pointer Publishers, Jaipur.

Guenther E. The essential oils. Vol 1-6.

Kumar N, Abdul Khader ML, Rangaswamy P & Ikrulappan I. 1994. Spices, Plantation Crops, Medicinal and Aromatic Plants. Rajalakshmi Publ.

Masada Y.1986. Analysis of Essential Oil by Gas Chromatograph and Mass Spectrometry. John Wiley & Sons.

Panda H. 2002. Medicinal Plants Cultivation and their Uses. Asia Pacific Business Press.

Peter KV. (Ed.). 2001. Handbook of Herbs and Spices. Vols.I-III. Wood Head Publishing Co., UK & CRC, USA.

Prajapati SS, Paero H, Sharma AK & Kumar T. 2006. A Hand book of Medicinal Plants. Agro Bios.

WHO. 1998. Quality Control Methods for Medicinal Plants Materials. WHO.

PHT 510 *IN-PLANT* TRAINING AND MANAGEMENT OF WASTE FROM HORTICULTURAL PROCESSING INDUSTRIES (1+1)

Theory: Waste & its consequences in pollution and global warming, Need for waste management. 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. 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: The student will be attached to a unit associated with commercial fresh produce handling, storage and marketing, where the student receives practical training in various aspects of post harvest handling *viz.,* harvesting, sorting and grading, pre-storage treatments, packing, storage, transport and marketing. Or the student will be attached to a processing unit where the student will attend to various unit operations involved in processing of different fruits, vegetables, spices or plantation crops. The student will maintain daily production schedule of finished products and utilization of raw material. The student has to understand and critically study the waste management practice in both fresh and processed product industries. The student is required to submit a detailed report of their training along with the layout plan of unit they attended.

Suggested References

Verma LR and Josh VR. 2000. Post harvest technology of fruits and vegetableshandling, processing, fermentation and waste management. Vol-2. Indus Publishing company.

Ioannis S. Arvanitoyannis. 2007. Waste Management for the Food Industries.

PHT 511 PROCESS ENGINEERING IN HORTICULTURAL CROPS (1+1)

Theory: Importance and scope, conveying and elevating equipment, physical and thermal properties of horticultural commodities; Rheological and textural

properties; Heating processes; Thermal process calculation; Heating equipment applied to processing *viz.,* jacketed pan, bath, plate and tubular heat exchanger; Evaporator in food industries, multiple effect and multistage evaporator, size reduction; Features and design specifications; Planning for domestic as well as commercial storage facilities; Drying equipment; Classification of filtration equipment and outline; Equipment in cannery; kinetics of growth and enzyme reactions; Fermentation; Equipment and product recovery; Discharge of industrial waste; Freezing equipment; Unit operations of processing.

Practicals: Handling of harvesting equipments; Determination of physical and thermal properties; thermal process calculations; Particle size analysis; Storage structure design; numerical problems in freezing; drying, conveying and calculations pertaining to texture and Rheology; Handling of heating equipment, pulper, juice extractor, deaerator, juice filters; Processing industries waste treatment; Working of a canning unit; Visit to commercial processing units and storage units.

Suggested References

Heldman DR and Singh RP.1984. Food Process Engineering. AVI Publ.

Romeo T. Toledo. Fundamentals of food process engineering, 2nd edition. CBS Publishers and Distributors.

Sahay KM & Singh KK. 1994. Unit Operation of Agricultural Processing.Vikas Publ. House.

Singh RP & Heldman DR. 1993. Introduction to Food Engineering. Academic

PHT 512 SAFETY IN HORTICULTURE FOOD CHAIN (2+0)

Theory: Horticulture food chain, Hazards – biological, chemical, physical; Quality assurance system and food safety; Challenges and opportunities for developing country exports; 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; Design and implementation of an HACCP system; Steps in the risk management process; Traceability in food supply chains; microbial and chemical analysis of food; Various organizations dealing with inspection, traceability and authentication, certification and quality assurance such as FSSA, APEDA, *etc.* Indian and International quality systems and standards like Codex Alimentarius, ISO, etc. Consumer perception of safety; Ethics in food safety.

Suggested Reference:

Export/Import policy by Govt. of India.

Graham HD. 1980. Safety of Foods. AVI Publ. Co.

Krammer A & Twigg BA.1973. Quality Control in Food Industry. Vol. I, II. AVI Publ.

Luning PA, Devlieghere F and Verhe R. 2007. Safety in the agri-food chain. Wageningen Academic Publishers.

Macrae R, Roloson R & Sadlu MJ. 1994. Encyclopedia of Food Science & Technology & Nutrition. Vol. XVI. Academic Press.

Peter KV. 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 SN. 2004. Food Safety: Concepts and Reality. APH Publ. Corp. Press.

BIOTECHNOLOGY AND CROP IMPROVEMENT

Course No	Course Title	Credits
	A.Core courses	
BCI 501	FUNDAMENTALS OF PLANT MOLECULAR BIOLOGY	3+0
BCI 502	PLANT TISSUE CULTURE AND GENETIC TRANSFORMATION	2+1
BCI 503	PRINCIPLES OF PLANT BREEDING	2+1
BCI 504	PRINCIPLES OF GENETICS AND CYTOGENETICS	2+1
BCI 505	PRINCIPLES OF SEED PRODUCTION	1+1
BCI 506	FLORAL BIOLOGY, SEED DEVELOPMENT & MATURATION	1+1
	TOTAL	**16**
	B.Optional Courses (Minimum 4 Courses)	
BCI 507	PRINCIPLES OF RECOMBINANT DNA TECHNOLOGY	2+1
BCI 508	TECHNIQUES IN MOLECUALR BIOLOGY- I	0+2
BCI 509	TECHNIQUES IN MOLECULAR BIOLOGY-II	0+2
BCI 510	MICROBIAL GENETICS AND INDUSTRIAL BIOTECHNOLOGY	2+1
BCI 511	MOLECULAR BREEDING	2+0
BCI 512	BIO-SAFETY, BIOETHICS, IPR AND SEED LEGISLATION	2+0
BCI 513	INTRODUCTION TO BIO-INFORMATICS	1+1
BCI 514	IMMUNOLOGY AND MOLECUALR DIAGNOSTICS	2+1
BCI 515	NANO BIOTECHNOLOGY	3+0
BCI 516	GENOMICS AND PROTEOMICS	2+0
BCI 517	ENVIRONMENTAL BIOTECHNOLOGY	3+0
BCI 518	PRINCIPLES OF QUANTITATIVE GENETICS	2+1
BCI 519	MUTATION BREEDING	1+1
BCI 520	HETEROSIS BREEDING	1+1

BCI 521	PLANT GENETIC RESOURCES	2+0
BCI 522	BREEDING FOR BIOTIC AND ABIOTIC STRESS TOLERANCE	2+1
BCI 523	BREEDING FOR QUALITY TRAITS IN HORTICULTURAL CROPS	2+1
BCI 524	BREEDING OF ANNUAL HORTICULTURAL CROPS	2+1
BCI 525	BREEDING OF PERENNIAL HORTICULTURAL CROPS	2+1
BCI 526	SEED PRODUCTION IN HORTICULTURAL CROPS	2+1
BCI 527	SEED QUALITY TESTING AND CERTIFICATION	2+1
BCI 528	SEED PROCESSING AND STORAGE	2+1
BCI 529	HYBRID SEED PRODUCTION	1+1
	TOTAL	**59**

A.CORE COURSES

BCI 501 FUNDAMENTALS OF PLANT MOLECULAR BIOLOGY (3+0)

Theory :

Unit I : Development of molecular biology; Nucleic acids as genetic material; Chemistry, structure and properties of DNA and RNA. Organelle genetics

Unit II : Genome organization of prokaryotes and eukaryotes; Chromatin structure and function; DNA replication; DNA polymerases, topoisomerases, DNA ligase, Molecular basis of mutations; transposons, reterotransposons, DNA repair mechanisms.

Unit III : Transcription RNA processing; Reverse transcriptase; RNA editing; Ribosomes structure and function; Organization of ribosomal proteins and RNA genes; Genetic code; Aminoacyl tRNA synthases. Transcription regulation in lower and higher organisms, biology of Si, Mi RNA.

Unit IV : Translation and post-translational modifications; Operon concept; trp operon; gene regulation in eukaryotes and prokaryotes. Eukaryotic and prokaryotes vectors: cloning, genomic library, cDNA library, ESTs, artificial chromosomes: YACs, BACs and MACs.. Heterologous gene expression, Expression vectors, role of the regulatory elements in expression of a gene, Ti plasmids and vectors for plant transformation, recent developments in the design and use of vectors.

Unit V : Molecular basis of photosynthesis, Plant responses to biotic and abiotic stress transcription elements, transcription factor, regulatory elements, signal transduction, prions

Suggested Readings

Lewin B. 2008. *Gene IX*. Peterson Publications/ Panima.

Malacinski GM & Freifelder D. 1998. *Essentials of Molecular Biology*. 3rd Ed. Jones & Bartlett Publishers.

Nelson DL & Cox MM. 2007. *Lehninger's Principles of Biochemistry*. W.H. Freeman & Co.

Primrose SB. 2001. *Molecular Biotechnology*. Panima.

Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. *Molecular Biology of the Gene*. 6th Ed. Pearson EducationInternational.

BCI 502 PLANT TISSUE CULTURE AND GENETIC TRANSFORMATION (2+1)

Theory

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

Unit II : Micropropagation; Anther and microspore culture, DH production, Somaclonal variation, *In vitro* mutagenesis and selelction, *In vitro* fertilization, *In vitro* germplasm conservation, Production of secondary metabolites, Synthetic seeds, *in vitro* micro grafting.

Unit III : Embryo rescue and wide hybridization; Protoplast culture and regeneration; Somatic hybridization: protoplast fusion, cybrids, asymmetric hybrids, Cryopreservation,

Unit IV : Methods of plant transformation; Vectors for plant transformation; marker and Reporter genes Genetic, stabilization and molecular analyses of transgenics; Target traits and transgenic crops; Role of transposons and reterotransposons in crop improvement, testing of transgenics

Practical

Laboratory set-up, structure and power logistics, economics

Preparation of media; handling and sterilization of plant material; inoculation, sub culturing plant regeneration and hardening

Meristem/shoot tip culture

Anther, pollen culture, DH production, ploidy analysis

Embryo rescue.

Suspension cultures and production of secondary metabolites.

Protoplast isolation, culture and fusion.

Gene transfer using Agrobacterium, selection of transformed tissues/ plants

Suggested References

Bhojwani SS. 1983. *Plant Tissue Culture: Theory and Practice*. Elsevier.

Christou P & Klee H. 2004. *Handbook of Plant Biotechnology*. John Wiley & Sons.

Dixon RA. 2003. *Plant Cell Culture*. IRL Press.

George EF, Hall MA & De Klerk GJ. 2008. *Plant Propagation by Tissue Culture*. Agritech Publ.

Gupta PK. 2004. *Biotechnology and Genomics*. Rastogi Publ.

Herman EB. 2005-08. *Media and Techniques for Growth, Regenerationand Storage*. Agritech Publ.

Pena L. 2004. *Transgenic Plants: Methods and Protocols*. Humana Press.

Pierik RLM. 1997. *In vitro Culture of Higher Plants*. Kluwer.

Singh BD. 2007. *Biotechnology: Expanding Horiozon.* Kalyani.

BCI 503 PRINCIPLES OF PLANT BREEDING (2+1)

Theory

Unit I : History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Plant introduction and role of plant genetic resources in plant breeding.

Unit II : Genetic basis of mating systems, consequences of Inbreeding, selfing and backcrossing.Genetic basis of breeding self- and cross - pollinated crops including and response to selection - nature of variability, Types of gene actions; components of Phenotypic value and components of variance; and implications in plant breeding; Heritability and Selection response, genotype environment interaction; Combining ability effects and variances (instead of stating only as GCA & SCA).

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

Unit IV : Breeding methods. Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites;

Unit V : Genetic architecture of horticulture crops, Turmeric, other clonally propagated crops of economic importance like grapes, difficulties in breeding clonally propagated crops and methods to improve the specific traits in clonally propagated crops.

Unit VI : Innovative breeding techniques for horticulture crops. Mutation breeding: Types of mutagens and classification; Dosimetry; Handling

segregating mutated material and selection for polygenic traits, mutation for specific trait improvement (few examples), hybridization followed by mutation, varieties released by mutation breeding, Breeding for biotic stresses, Gene for gene concept, concept of differentials in resistance breeding, Concept of Vertical and Horizontal resistance, Multilines, wide hybridization. IPR and varietal release and maintenance

Practical: Floral biology in self and cross pollinated species, Selfing and crossing techniques in different crop plants. Evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance. Maintenance of experimental records. Selection methods in segregating populations; Field Visits and practical exposure for study of segregating generations in horticulture crops.

Suggested References

Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.

Chopra VL. 2001. *Breeding Field Crops*. Oxford & IBH.

Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.

Gupta SK. 2005. *Practical Plant Breeding*. Agribios.

Pohlman JM & Bothakur DN. 1972. *Breeding Asian Field Crops*. Oxford & IBH.

Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*.Narosa Publ. House.

Sharma JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.

Simmonds NW. 1990. *Principles of Crop Improvement*. English Language Book Society.

Singh BD. 2006. *Plant Breeding*. Kalyani.

Singh P. 2002. *Objective Genetics and Plant Breeding*. Kalyani.

Singh P. 2006. *Essentials of Plant Breeding*. Kalyani.

Singh S & Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*.CBS.

BCI 504 PRINCIPLES OF GENETICS AND CYTOGENETICS (2+1)

Theory

Unit I : Genetics: Meaning and scope; Beginning of genetics; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper; Mitosis. Meiosis and life cycles; Chromosomal theory of inheritance.

Unit II : Types of dominance, multiple alleles, genotypic interactions, types and mechanism; inborn errors of metabolism, one gene- one enzyme hypothesis

Unit III : Probability and Statistics as applied to genetics, Binomial theorem, hypothesis testing and Chi-square test

Unit IV : Sex determination, Dosage compensation, Sex linkage, sex limited and sex influenced traits, pedigree analysis, Penetrance and expressivity

Unit V : Linkage and mapping in eukaryotes: Diploid mapping, haploid mapping(tetra analysis), genetic maps

Unit VI : Non-Mendelian inheritance: maternal effects and cytoplasmic inheritance. Mitochondria, chloroplasts and infective particles; Imprinting

Unit VII : Processes that change allelic frequencies: Mutation, migration, small population size and random genetic drift, natural selection and selection models, selection-mutation equilibrium

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

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

Unit X : Structural and Numerical variations of chromosomes and their implications- Symbols and terminologies for chromosome numbers - euploidy -haploids, diploids and polyploids ; Utilization of aneuploids in gene location - Variation in chromosome behaviour - somatic segregation and chimeras – endomitosis and somatic reduction ; Evolutionary significance of chromosomal aberrations – balanced lethals and chromosome complexes.

Unit XI : Inter-varietal chromosome substitutions; Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids vs allopolyploids –- Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks

transfer – Alien addition and substitution lines – creation and utilization; Apomixis - Evolutionary and genetic problems in crops with apomixes.

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

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

Practical : Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; problems solving on the fate of genes in populations. Microscopy: various types of microscopes, - Observing sections of specimen using Electron microscope; Preparing specimen for observation – Fixative preparation and fixing specimen for light microscopy studies in vegetables, Studies on the course of mitosis in onion and *Aloe vera* Using micrometers and studying the pollen grain size in various crops -Various methods of staining and preparation of temporary and permanent slides - Pollen germination *in vivo* and *in vitro;* Agents employed for the induction of various ploidy levels; Solution preparation and application at seed, seedling level - Identification of polyploids in different crops - Induction and identification of haploids; Anther culture and Ovule culture – Morphological observations on synthesized autopolyploids - Observations on C-mitosis, learning on the dynamics of spindle fibre assembly – Morphological observations on alloployploids - Morphological observations on aneuploids – Cytogenetic analysis of interspecific and intergeneric crosses -Maintenance of Cytogenetic stocks and their importance in crop breeding -Various ploidy levels due to somaclonal variation ; Polyploidy in ornamental crops.

Suggested References

Gardner EJ & Snustad DP. 1991. *Principles of Genetics*. John Wiley &Sons.

Klug WS & Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu.

Lewin B. 2008. *Genes IX*. Jones & Bartlett Publ.

Russell PJ. 1998. *Genetics*. The Benzamin/Cummings Publ. Co.

Snustad DP & Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley & Sons.

Strickberger MW. 2005. *Genetics (III Ed)*. Prentice Hall, New Delhi, India

Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs.

Uppal S, Yadav R, Subhadra & Saharan RP. 2005. *Practical Manual on*

Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall.

Darlington CD & La Cour LF. 1969. *The Handling of Chromosomes*.

Gray P. 1954. *The Mirotomist's Formulatory Guide*. The Blakiston Co.

Gupta PK. 2000. *Cytogenetics*. Rastogi Publ.

Johannson DA. 1975. *Plant Microtechnique*. McGraw Hill.

Karp G. 1996. *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons.

Khush GS. 1973. *Cytogenetics of Aneuploids*. Academic Press.

Sharma AK & Sharma A. 1988. *Chromosome Techniques: Theory and Practice*. Butterworth.

BCI 505 PRINCIPLES OF SEED PRODUCTION (1+1)

Theory

Unit I : Introduction : Seed quality concept and importance of genetic purity in seed production; types of cultivars, their maintenance and factors responsible for deterioration; seed production in self and cross pollinated crops.

Unit II : Mode of pollination and reproduction in horticulture crop plants. Principles of hybrid seed production, isolation distance, roguing *etc.* male sterility and incompatibility system in hybrid seed production, role of pollinators and their management.

Unit III : Seed multiplication ratios, seed replacement rate, demand and supply; suitable areas of seed production and storage, agronomy of seed production – agro climatic requirements and their influence on quality seed production; generation system of seed multiplication; Genetic basis of nuclear and breeder seed maintenance, varietal run down, renovation, and maintenance of varietal purity. Quality assurance through conventional and molecular approach. Maintenance of Nucleus seed, production of Breeder, Foundation and Certified. Seed and field standards for horticultural crops.

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

Unit V : Genetic basis of nucleus and breeder seed maintenance, varietal rundown, renovation and maintenance of varietal purity. Seed quality assurance through conventional and molecular approaches. Seed quality control system and organization, seed village concept; Seed production agencies, seed industry and custom seed production in India.

Practical : Seed production planning in different crops with special reference to land and isolation requirements. Agronomic management, rouging,harvesting and threshing in horticulture crops. Characters of important varieties and its maintenance. Nucleus, breeder, foundation and certified seed production in horticultural crops. Hybrid seed production, planting ratio of male and female parental line, pollen collection, supplementary pollination, pollen storage, hand pollination in horticulture crops. Gametocide application and observation. Visit to Horticulture seed production plots.

Suggested 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.

Musil AF. 1967. *Identification of Crop and Weed Seeds*. Handbook No. 219, USDA, Washington, DC, USA.

Poehlman JM & Sleper DA. 2006. *Breeding Field Crops*. Blackwell.

Singh BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani.

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

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

BCI 506 FLORAL BIOLOGY, SEED DEVELOPMENT (1+1)

AND MATURATION

Theory

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

Unit II : Fertilization – embryo substructure, process, barriers to fertilization, incompatibility and male sterility, factors affecting fertilization.

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

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

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

Suggested References

Bhojwani SS & Bhatnagar SP. 1999. *The Embryology of Angiosperm*. Vikas Publ.

Black M, Bewley D & Halmer P. 2006. *The Encyclopedia of Seeds:Science, Technology and Uses*. CABI.

Chhabra AK. 2006. *Practical Manual of Floral Biology of Crop Plants*.Deptt. of Plant Breeding, CCS HAU, Hisar.

Copeland LO & McDonald MB. 2001. *Principles of Seed Science andTechnology*. 4th Ed. Chapman & Hall.

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

B.OPTIONAL COURSES

BCI 507 PRINCIPLES OF RECOMBINANT DNA TECHNOLOGY (2+1)

Theory

Unit I: Developments in Eukaryotes and prokaryotic genomes. Organization of prokaryotic genome. Plasmids of E. coli. Life cycle of bacteriophages.

Unit II: Restriction enzymes: discovery, types of restriction enzymes. restriction mapping. Ligases, Enzymes involved construction of recombinants (kinases, phosphatases, DNA and RNA Polymerases, DNase, terminal transferases, nucleases). Creating recombinant DNA molecules. Fate of foreign DNA in a host cell.

Unit III: Nature of marker and reporter genes used in prokaryotes and eukaryotes, Principal requirements for making a genomic library. Features of cloning vectors, cosmids Genomic library:

Unit IV: Choice of enzyme and vector, features of the host cell used for transformation, nature of the genomic library. cDNA and its cloning, construction of cDNA libraries. Nature of cDNA libraries. Selection of desired clones from the genomic and cDNA libraries.

Unit V: Nucleic acid electrophoresis. Nucleic acid probes, methods of labeling probes and hybridization methods - southern, northern. Chemical synthesis of DNA and sequencing.

Unit VI: Polymerase chain reaction (PCR), its nature and applications. Antisense RNA technology. RNAi technology, Site directed mutagenesis. Principles and construction of SSH library. Construction of expression vector, affinity purification of engineered proteins, detection, western and ELISA analysis

Practicals: Genomic DNA Extraction, Plasmid DNA extraction from Bacteria, restriction Digestion of DNA, Recombinant DNA construction, preparation of Competent cells, Transformation and selection of transformants, PCR confirmation of the transformants, Genomic Library construction, cDNA preparation, cloning and transformation, construction of expression vector and SDS PAGE, cloning gene in plant transformation vector, PCR, transformation of plant transformation vector to Agrobacterium and confirmation.

Suggested References

Kun LY. 2006. *Microbial Biotechnology*. World Scientific.

Sambrook J & Russel DW. 2001. *Molecular Cloning: a LaboratoryManual.* Cold Spring Harbour Lab. Press.

Twyman RM. 2003. *Advanced Molecular Biology*. Bios Scientific.

BCI 508 TECHNIQUES IN MOLECULAR BIOLOGY-I (0+2)

Practical

UNIT I : Good lab practices; Biochemical techniques: Preparation of buffers and reagents

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

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

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

Suggested References

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA &

Struhl K. 2002. *Short Protocols in Molecular Biology*. John Wiley.

Kun LY. 2006. *Microbial Biotechnology*. World Scientific.

Sambrook J, Russel DW & Maniatis T. 2001. *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbour Laboratory Press.

BCI 509 TECHNIQUES IN MOLECULAR BIOLOGY-II (0+2)

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

Practical : Construction and screening genomic and cDNA library, Synthesis and cloning of cDNA and RTPCR analysis; Real time PCR and interpretation of data. Molecular markers (RAPD, SSR, AFLP , candidate genes) and their analysis; Case study of SSR markers (linkage map, QTL analysis etc); SNP

identification and analysis; Microarray and tag based gene based discovery methods- 5'3'SAGE, RATE, CAGE and MPSS and use of relevant software.Proteomics (2D gels, mass spectrometry, etc.); RNAi (right from designing of construct to the phenotyping of the plant); Yeast 1 and 2-hybrid interaction. Generation and screening of mutants; Transposon mediated mutagenesis.

Suggested References

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. *Short Protocols in Molecular Biology*. Wiley.

Caldwell G, Williams SN & Caldwell K. 2006. *Integrated Genomics: A Discovery-Based Laboratory Course*. John Wiley.

Sambrook J, Russel DW & Maniatis T. 2001. *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbour Laboratory Press.

BCI 510 MICROBIAL GENETICS AND INDUSTRIAL BIOTECHNOLOGY (2+1)

Theory

Unit I : Development of the gene concept, Microbial genome, molecular nature of genes, genetic code, gene expression and its regulation. Transcription apparatus in microbes, operon concept, regulatory circuits. Phage strategies: lytic and lysogenic lifestyles, use of regulatory elements in rDNA technology, DNA protein interaction in prokaryotes- translation. DNA replication and repair mechanisms, mutations in microbes, restriction modification systems, recombination, transposons, , molecular mechanism of transformation, conjugation and transduction, Forward and reverse genetic approaches,

Unit II : Use of microbial systems for cloning and expression, Vehicles of gene cloning: plasmids, bacteriophages. Detailed description of the plasmids of bacteria-biology, replication, segregation, incompatibility, classification, *in vivo* cloning systems. Gene cloning. Prokaryotic vectors: design of vectors, components of cloning vectors, types of cloning vectors, uses of the cloning vectors. Study of gene expression- E coli as a host for expression, Expression vectors, role of the regulatory elements in expression of a gene,

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

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

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

UNIT VI : Industrial biotechnology for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bioremediation of soil; Production of eco-friendly agricultural chemicals, biopesticides, bio-herbicides, bio-fertilizers, bio-fuels, *etc.*

Practical

i. Isolation of industrially important microorganisms, their maintenance and improvement.

ii. Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery.

iii. Study of bio-reactors and their operations.

iv. Production of biofertilizers.

v. Experiments on microbial fermentation process, harvesting purification and recovery of end products.

vi. Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomass estimation.

vii. Determination mass transfer co-efficients.

Suggested References

Huffnagle GB & Wernick S. 2007. *The Probiotics Revolution: TheDefinitive Guide to Safe, Natural Health*. Bantam Books.

Kun LY. 2006. *Microbial Biotechnology*. World Scientific.

Primrose SB. 2001. *Molecular Biotechnology*. Panima.

BCI 511 MOLECULAR BREEDING (2+0)

Theory

Unit I : Principles of plant breeding, Introduction of Breeding methods in Horticulture crops, Advantages of molecular breeding, genetic basis of markers

Unit II : Characteristics of different molecular markers, Development of mapping populations, phenotyping and genotyping (conventional and high through put) and linkage map construction. Advanced methods of genotyping; Mapping genes for qualitative and quantitative traits. Annotation of markers and QTLs using bioinformatics.

Unit III : QTL mapping using structured populations; AB-QTL analysis; Association mapping; Fine-mapping of genes/QTL; Map based gene/QTL isolation and development of gene based markers; Allele mining by TILLING and Eco-TILLING; Validation of molecular markers.

Unit IV : Marker assisted breeding in horticulture crops with case studies, Foreground and background selection; MAS for gene introgression, stacking and pyramiding, Transgenic breeding. Marker and gene databases in molecular breeding of horticulture crops

Suggested References

Chittaranjan K. 2006-07. *Genome Mapping and Molecular Breeding in Plants.* Vols. I-VII. Springer.

Newbury HJ. 2003. *Plant Molecular Breeding*. Blackwell Publ.

Weising K, Nybom H, Wolff K & Kahl G. 2005. *DNA Fingerprinting inPlants: Principles, Methods and Applications*. Taylor & Francis.

BCI 512 BIOSAFETY, BIOETHICS, IPR AND SEED LEGISLATION (2+0)

Theory

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

Unit II : General principles for the laboratory and environmental biosafety; Health aspects; toxicology, allergenicity, antibiotic resistance, Impact on environment: gene flow in natural and artificial ecologies; Sources of gene

escape, tolerance of target organisms, creation of superweeds/super organisms

Unit III : Ecological aspects of GMOs and impact on biodiversity; Monitoring strategies and methods for detecting transgenics; Radiation safety and nonradio isotopic procedure; Benefits of transgenics to human health, society and environment.

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

Unit V : Legislation for Seed quality: concept and factors affecting seed quality during different stages of production, processing and handling; seed quality control- concept and objectives; Central Seed Certification Board (CSCB)

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

Suggested References

Singh BD. 2007. *Biotechnology: Expanding Horizon*. Kalyani.

http://patentoffice.nic.in

www.wipo.org

www.dbtindia.nic.in

www.dbtbiosafety.nic.in

Agarwal RL. 1997. *Seed Technology*. Oxford & IBH.

Anonymous 1992. *Legislation on Seeds*. NSC Ltd., Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi.

BCI 513 INTRODUCTION TO BIOINFORMATICS (1+1)

Theory: Introduction, biological databases – primary, secondary and structural, Protein and Gene Information Resources – NCBI, EMBL, PIR, SWISSPROT, PDB, DDBJ. Specialized genomic resources. DNA sequence analysis, cDNA libraries and EST, EST analysis, pairwise alignment techniques database searching, multiple sequence alignment. Secondary database searching, building search protocol, computer aided drug design – basic principles, docking, QSAR. Analysis packages – commercial databases and packages, GPL software for Bioinformatics, web-based analysis tools. Genome annotations, prediction of structure, function of proteins and nucleic acids.

Practical : Usage of NCBI resources, acquisition of protein and nucleic data base, BLAST search analysis, Retrieval of sequence/structure from databases, analysis of conserved motifs, construction of dendograms, prediction of structure function of proteins and the genomes (ESTs, Genomic sequences), Visualization of structures, Docking of ligand receptors

Suggested References

Attwood TK & Parry-Smith DJ. 2003. *Introduction to Bioinformatics*. Pearson Education.

Rastogi SC, Mendiratta N & Rastogi P. 2004. *Bioinformatics: Concepts,Skills and Applications*. CBS.

BCI 514 IMMUNOLOGY AND MOLECULAR DIAGNOSTICS (2+1)

Theory

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

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

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

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

Practical

i. Preparation of buffers and reagents.

ii. Immunoblotting, immunoelectrophoresis and fluorescent antibody test.

iii. Enzyme immunoassays including ELISA western blotting.

iv. Extraction and identification of DNA/RNA of pathogenic organisms.

v. Restriction hybridoma technique and production of monoclonal antibodies.

vi. Immunogenic proteins, expression and immunogenecity studies, purification of immunogenic protein and immunization of laboratory animals.

Suggested References

Bloom BR & Lambert P-H. 2002. *The Vaccine Book*. Academic Press.

Elles R & Mountford R. 2004. *Molecular Diagnosis of Genetic Disease*. Humana Press.

Kindt TJ, Goldsby RA & Osbrne BA. 2007. *Kuby's Immunology*. WH Freeman.

Levine MM, Kaper JB, Rappuoli R, Liu MA & Good MF. 2004. *New Generation Vaccines*. 3rd Ed. Informa Healthcare.

Lowrie DB & Whalen R. 2000. *DNA Vaccines*. Humana Press.

Male D, Brostoff J, Roth DB & Roitt I. 2006. *Immunology.* Elsevier.

Rao JR, Fleming CC & Moore JE. 2006. *Molecular Diagnostics*. Horizon Bioscience.

Robinson A & Cranage MP. 2003. *Vaccine Protocols*. 2nd Ed. Humana Press.

Spinger TA, 1985. *Hybridoma Technology in Biosciences and Medicine*. Plenum Press.

BCI 515 NANO-BIOTECHNOLOGY (3+0)

Theory :Unit I : Introduction to Biomacromolecules: The modern concepts to describe the conformation and dynamics of biological macromolecules:

scattering techniques, micromanipulation techniques, drug delivery applications etc.

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

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

Unit IV : Preparation and characterization of nanoparticles; Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nanoimaging, Metabolic engineering and Gene therapy.

Suggested References

Nalwa HS. 2005. *Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology*. American Scientific Publ.

Niemeyer CM & Mirkin CA. 2005. *Nanobiotechnology*. Wiley Interscience.

BCI 516 GENOMICS AND PROTEOMICS (2+0)

Theory

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

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

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

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

Suggested References

Gibson G & Muse SV. 2004. *A Primer of Genome Science*. Sinauer Associates.

Primrose SB & Twyman RM. 2007. *Principles of Genome Analysis and Genomics.* Blackwell.

Sensen CW. 2005. *Handbook of Genome Research*. Vols. I, II Wiley-CVH

BCI 517 ENVIRONMENTAL BIOTECHNOLOGY (3+0)

Theory

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

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

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

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

Suggested References

Evans GM & Furlong JC. 2002. *Environmental Biotechnology: Theory and Application*. Wiley International.

Jordening H-J & Winter J. 2006. *Environmental Biotechnology: Concepts and Applications*. Wiley-VCH Verlag.

BCI 518 PRINCIPLES OF QUANTITATIVE GENETICS (2+1)

Theory

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

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

Unit III : Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D2 analyses - Association analysis - phenotypic and genotypic and genetic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; concept of selection response correlated response Selection indices – selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance.

Unit IV : Generation mean analysis**,** Mating designs, N C designs, Combining ability effects and variances, Modifications of NC Designs, L x T and Diallel analysis. Concept of G x E interaction and analysis of G x E interaction, Adaptability and stability parameters. AMMI analysis - Principles and interpretation

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

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

Practical:ANOVA, Estimation of variance components, Estimation of heterosis D2 Analysis and grouping of genotypes, interpretation. ANCOVA, Correlation and path Analysis NC Designs and modifications L x T analysis. Dialed Analysis –Components of variance and Combining ability analysis. Generation mean analysis: Estimation of effects, variances and interpretation. Partitioning of variance covariance into components G x E

interaction and stability analysis AMMI analysis ANCOVA, correlation and path analysis. Estimation of inbreeding depretion and heterosis. Working out efficiency of selection efficiency in populations from different methods. Phenotype linkage studies - Working out efficiency of selection methods in different populations and interpretation.

Suggested References

Bos I & Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.

Falconer DS & Mackay J. 1998. *Introduction to Quantitative Genetics*. Longman.

Mather K & Jinks JL. 1971. *Biometrical Genetics*. Chapman & Hall.

Mather K & Jinks JL. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall.

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

Naryanan SS & Singh P. 2007. *Biometrical Techniques in Plant Breeding. Kalyani.*

Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani.

Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani.

Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.

Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

BCI 519 MUTATION BREEDING (1+1)

Theory

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

Unit II : Mutagenic agents: physical — Radiation types and sources: Ionising and non-ionizing radiations *viz.,* X rays, á rays, â rays and " rays particles, protons, neutrons and UV rays - Radiobiology: mechanism of action of various

radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects –RBE and LET relationships.

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

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

Unit V : Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras etc., - Observing mutagen effects in M2 generation - Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations -– Mutations in traits with continuous variation.

Unit VI : Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage *etc.* - Individual plant based mutation analysis and working out effectiveness and efficiency in M3 generation - Comparative evaluation of physical and chemical mutagens for creation of variability in the same species – Case studies.

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

Unit VIII : Use of mutagens in genomics, allele mining, TILLING.

Practical : Learning the precautions on handling of mutagens; Dosimetry - Studies of different mutagenic agents: Physical mutagens - Studies of different mutagenic agents: Chemical mutagens - Learning on Radioactivity – Production

of source and isotopes at BRIT, Trombay - Learning about gamma chamber; Radiation hazards - Monitoring – safety regulations and safe transportation of radioisotopes - Visit to radio isotope laboratory ; learning on safe disposal of radioisotopes - Hazards due to chemical mutagens - Treating the plant propagules at different doses of physical and chemical mutagens - Learning combined mutagenic treatments; Raising the crop for observation - Mutagenic effectiveness and efficiency; Calculating the same from earlier literature - Study of M1 generation – Parameters to be observed; Study of M2 generation – Parameters to be observed; Mutation breeding in cereals and pulses – Achievements made and an analysis - Mutation breeding in oilseeds and cotton – Achievements and opportunities- Mutation breeding in forage crops and vegetatively propagated crops; Procedure for detection of mutations for polygenic traits in M2 and M3 generations.

Suggested References

Cotton RGH, Edkin E & Forrest S. 2000. *Mutation Detection: A Practical Approach*. Oxford Univ. Press.

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BCI 520 HETEROSIS BREEDING (1+1)

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

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

Unit III : Prediction of heterosis from various crosses- Inbreeding depression, effects of inbreeding on genotypic frequency and population mean, frequency of inbreeding and residual heterosis in F2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies. Relationship between genetic distance and expression of heterosis – case studies; Divergence and Genetic Distance analyses-morphological and molecular genetic distance in predicting heterosis, Concept of combining ability. Development of heterotic pools /genetic stocks and inbreds, their improvement for increasing heterosis.

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

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

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

Unit VII : Heterosis breeding in maize, vegetable crops.

Practical : Male sterile line characterization using morphological descriptors; Restorer line identification and diversification of male sterile sources - Male sterile line creation in oilseeds, pulses, cotton and cereals; problems in creation of CGMS system; Ways of overcoming them ,use of gametocides in inducing male-sterility.- Apomixis: practical applications and difficulties in breeding; Estimation from the various models for heterosis parameters - Hybrid seed production in field crops – an account on the released hybrids. Hybrid breeding at National and International level; Opportunities ahead.

Suggested References

Proceedings of *Genetics and Exploitation of Heterosis in Crops* – An International Symposium CIMMYT, 1998.

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BCI 521 PLANT GENETIC RESOURCES (2+0)

Theory

Unit I : Historical perspectives and need for PGR conservation; Importance of plant genetic resources; Gene pool: primary, secondary and tertiary; Centers of origin and global pattern of diversity; Basic and derived genetic resources.

Unit II : Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloging of PGR; Plant quarantine and phytosanitary certification; Germplasm introduction and exchange.

Unit III : Concept of population and gene pool; Variations in population and their classification; Gene frequencies in populations, rare and common alleles; Gene pool sampling in self and cross pollinated and vegetatively propagated species; Non-selective, random and selective sampling strategies; Coarse and fine grid surveys.

Unit IV : Germplasm conservation- *in situ, ex situ*, and on-farm; short, medium and long term conservation strategies for orthodox and recalcitrant seed and vegetatively propagated crops; Concept of base and active collections; crop descriptors, germplasm bank management. Principles of *in vitro* and cryopreservation.

Unit V : PGR and data base management; Multivariate and clustering analysis, descriptors; Germplasm databases/ collection directories/ systems (GRIN, EURISCO, SINGER, WIEWS, IN-PGRS); National and international protocols for PGR management; International Treaty on PGR for food and agriculture (ITPGRFA), Standard Material Transfer Agreement (STMA) and list of crops covered under multilateral system (Annex I). PGR access and benefit sharing; Role of CGIAR system in the germplasm exchange; PBR, Farmers rights and privileges, comm. Unity rights; Seed Act, *sui generis* system; IPR, UPOV and CBD issues and consequences.

Unit VI : Variety Development and Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, hybrid and population; Variety testing, release and notification systems in India and abroad. Genetic purity concept and maintenance breeding. DUS Testing; Procedure/format for Registration of plant genetic resources with NBPGR and PPV & FR Authority.

Unit VII : Management and Utilization of genetic resources, concept of core and mini-core collections,molecular markers and their use in characterization; Evaluation and utilization of genetic resources including wild relatives; Pre-breeding / genetic enhancement for crop improvement with case studies. Visit to active and long term germplasm banks

Suggested References

Frankel OH & Bennett E. 1970. *Genetic Resources in Plants – their Exploration and Conservation*. Blackwell.

Gautam PL, Dass BS, Srivastava U & Duhoon SS. 1998. *Plant Germplasm Collecting: Principles and Procedures*. NBPGR, New Delhi.

Painting KA, Perry MC, Denning RA & Ayad WG. 1993. *Guide Book for Genetic Resources Documentation*. IPGRI, Rome, Italy.

Paroda RS & Arora RK. 1991. *Plant Genetic Resources, Conservation and Management. Concepts and Approaches*. IPGRI Regional office for South and South Asia, New Delhi.

Puzone L & Hazekamp TH. 1996. *Characterization and Documentation of Genetic Resources Utilizing Multimedia Database*. NBPGR, New Delhi.

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BCI 522 BREEDING FOR BIOTIC AND ABIOTIC STRESS TOLERANCE (2+1)

Theory

Unit I : Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses – pests and diseases of horticulture crops. Host defence responses to pathogens. gene-for-gene hypothesis, Concept of signal transduction and other host defense mechanisms. Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants.

Unit II : Phenotypic screening methods for major pests and diseases, use of trait specific markers, Correlating the observations, Gene pyramiding and stacking methods.

Unit IV : Classification of abiotic stresses. Conventional and Molecular breeding methods (such as temperature, salinity water, minerals, alkanity).

Unit V : Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging & submergence, high and low/freezing temperatures; Utilizing MAS procedures for identifying resistant types in horticulture crops

Practical : Screening techniques for biotic and abiotic stresses. Molecular screening for abiotic and biotic stresses. MAS for components associated with biotic and abiotic stress tolerance.

Suggested References

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van der Plank JE. 1982. *Host-Pathogen Interactions in Plant Disease*. Academic Press.

BCI 523 BREEDING QUALITY TRAITS IN HORTICULTURE CROPS (2+1)

Theory: Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Nutritional improvement - A human perspective – Golden rice- a case study, Breeding strategies achievements and application. Molecular basis of quality traits and their manipulation in tomato – Post harvest manipulation for quality improvement.

Breeding for cooking qualities in fruits, vegetables spices, medicinal and aromatic plants

Genetic engineering protocols for quality improvement – Achievements made - Value addition in crops; Classification and importance – Nutriogenomics and Second generation transgenics, nuetraceuticals. Metabalomics in medicinal and aromatic plants.

Practical : Fruit Quality evaluation in tomato, chilli, mango; Correlating ageing and quality improvement in tomato, potato – Quality analysis in vegetables; Estimation of antinutritional factors like tannins in different varieties/ hybrids: comparison ; Quality parameters evaluation in fruits, spices and vegetables; Quality parameters evaluation in Fruits; Quality parameters evaluation in spices; Value addition in crop plants; Post harvest processing of major vegetable and spice crops. Organoleptic evaluation.

Suggested References

Chahal GS & Ghosal SS. 2002. *Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches*. Narosa Publ.

Chopra VL. 1997. *Plant Breeding*. Oxford & IBH.

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Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.

Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.

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Singh RK, Singh UK & Khush GS. 2000. *Aromatic Rices*. Oxford & IBH.

BCI 524 BREEDING OF ANNUAL HORTICULTURAL CROPS (2+1)

Theory

Unit I : Solanaceous vegetables: Evolution and distribution of species and forms - wild relatives and germplasm; Genetics - cytogenetics and genome relationship - Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc. Hybrid tomato breeding- potential and outcome & its implications

Unit ll : Cole crops: Evolution and distribution of species and forms - wild relatives and germplasm; cytogenetics and genome relationship; Breeding objectives yield, quality characters, biotic and abiotic stress resistance, exploitation of heterosis *etc;* Cucurbits : Evolution and distribution of species and forms -wild relatives and germplasm - cytogenetics and genome relationship -Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc; Rose: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters *etc.*

Unit lll : Gladilolus: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance *etc* . QPM and Bt brinjal - strategies and implications Heterosis breeding attempts taken in brinjal, Minor flower crops: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship.

Unit lV : Distinguishing features of popular released varieties in vegetable and flower crops and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed production.

Practical : Floral biology - emasculation - pollination techniques ; Study of range of variation for yield and yield components - Study of segregating populations and their evaluation - Trait based screening for stress resistance in crops of importance- Use of descriptors for cataloguing Germplasm maintenance; learning on the Standard Evaluation System (SES) and descriptors;Use of softwares for database management and retrieval. Practical learning on the cultivation of vegetables crops on sewage water; analysing them for yield components and palatability; Laboratory analysis of vegetables for crude protein, digestibility percent and other quality attributes; ,

Suggested References

Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons.

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Singh BD. 1983. *Plant Breeding*. Kalyani.

Singh PK, Dasgupta SK & Tripathi SK. 2004. *Hybrid Vegetable Development*. International Book Distributing Co.

Swarup V. 1976. *Breeding Procedure for Cross-pollinated Vegetable Crops*. ICAR.

BCI 525 BREEDING OF PERENNIAL HORTICULTURAL CROPS (2+1)

Theory

Unit I : Banana: Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship; Morphological and molecular descriptors used for differentiating the accessions; Breeding objectives- yield, quality characters, biotic and abiotic stress etc.,

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

Unit lll : Other fruit crops: Grapes, Pineapple, Sapota, Citrus, pomegranate: Evolution, cytogenetics and genome relationship; Learning the descriptors; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc;* lnterspecific crosses attempted and its implications, reasons for failure, ways of overcoming them

Unit lV : Coconut: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Copra attd Oil yield characters; Breeding objectives- yield, quality characters, biotic and abioticstress etc.

Unit V : Arecanut & Betel vine : Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress etc; Oil quality - characteristics in different oils; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship.

Unit Vl : Cardamom and pepper: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress *etc.* - Oil quality - characteristics; Evolution and distribution of species and forms; Wild relatives and germplapm; Genetics, cytogenetics and genome relationship.

Unit Vll : Other plantation crops: Coffee, Rubber, Cocoa: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress.

Practical : Use of descriptors for cataloguing - Floral biology - emasculation - pollination techniques; Study of range of variation for yield and yield components - Study of populations in fruit crops and plantation crops. Use of descriptors for cataloguing - Floral biology, emasculation, pollination techniques of fruits crops like Guava, sapota, Jack and Jamun. Development and maintenance of male sterile lines in fruit crops.

Suggested References

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

Ferwerden FP & Wit F. (Ed.). 1969. *Outlines of Perennial Crop Breeding in the Tropics*. H. Veenman & Zonen

BCI 526 SEED PRODUCTION IN HORTICULTURE CROPS (2+1)

Theory

Unit I : Introduction; modes of propagation in important horticulture crops. Seed morphology and development in horticulture crops. Classification of vegetables, fruits, flower and plantation crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops.

Unit II : Share of vegetable seeds in seed industry; importance and present status of vegetable industry. Methods of seed production; comparison between different methods e.g. seed-to-seed vs. root-to-seed method in radish; seed multiplication ratios in horticulture crops; pollination mechanisms; sex types, ratios and expression and modification of flowering pattern in cucurbits; nursery raising and transplanting stage.

Unit III: Seed production technology of vegetables *viz.* solanaceous, cucurbitaceous, leguminous, malvaceous, cole crops, leafy vegetables, root, tuber and bulb crops and spices; harvesting/picking stage and seed extraction in fruit vegetables;clonal propogation and multiplication in tuber crops

eg.Potato, sweet potato, tapioca; seed-plot technique in potato tuber seed production; hybrid seed production technology of vegetable crops, TPS (true potato seed) and its production technique; hybrids in vegetables; maintenance of parental lines; use of male sterility and self incompatibility in hybrid seed production, environmental factors related to flowering/bolting in vegetable crops.

Unit IV : Flowers and Medicinal Plants; technology for quality seed production in important flower species i.e. marigolds, petunias, dahlia, roses, gladiolus, chrysanthemum etc; development of hybrids and their seed production technology of flower plants. Seed production technology of annual medicinal plants *viz.,* isabgol, ashawagandha *etc.*

Unit V : Fruit and Plantation Crops: role of seed in perennial plant species; nursery requirement, planning and management, seed orchards, seed collection, extraction and processing.

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

Suggested References

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George RAT. 1980. *Vegetable Seed Technology. A Technical Guide to Vegetable Seed Production, Processing, Storage and Quality Control.* FAO, Rome.

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BCI 527 SEED QUALITY TESTING AND CERTIFICATION (2+1)

Theory

Unit I : Introduction, objectives, concept and components and their role in seed quality control; instruments, devices and tools used in seed testing. ISTA and its role in seed testing.

Unit II : Testing of physical purity, seed moisture, germination, viability, vigour and dormancy

Unit III : 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 of transgenic plants / GM crops.

Unit IV : Seed health Testing: testing and detection methods for seed borne fungi, bacteria, viruses and nematodes.

Unit V : Seed Certification- history, concept and objectives of seed certification; seed certification agency/ organization; legal status and phases of seed certification; Indian Minimum Seed Certification Standards (I.M.S.C.S.) and field standards for horticultural crops and GM varieties.Planning and management of seed certification programmes.

Unit VI : Field Inspection- principles, phases and procedures; genetic purity evaluation (grow-out tests); post harvest inspection and evaluation; seed sampling, testing, labeling, sealing and grant of certificate; types and specifications for tags and labels.

Practical : 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, seed germination testing in different horticultural crops; seedling valuation; viability testing by tetrazolium test in different crops; seed and seedling vigour tests; genetic purity testing by chemical, biochemical and molecular methods; seed health testing for designated diseases.

General procedure of seed certification ; field inspection at different stages of a crop and observations recorded; inspection and sampling at harvesting/ threshing, processing and after processing for seed law enforcement; visits to regulatory seed testing laboratory, including plant quarantine lab and seed certification agency. Analysis of transgenics through kit .

Suggested References

Agarwal RL. 1997. *Seed Technology*. Oxford & IBH.

Agrawal PK & Dadlani M.1992. *Techniques in Seed Science and Technology*. 2nd Ed. South Asian Publ.

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

BCI 528 SEED PROCESSING AND STORAGE (2+1)

Theory

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

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

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

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

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

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

Suggested References

Agrawal RL. 1996. *Seed Technology*. Oxford Publ.

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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 529 HYBRID SEED PRODUCTION (1+ 1)

Theory

UNIT I : Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in agricultural, horticultural and other crop plants for crop improvement.

UNIT II : Pre requisites for hybrid seed production; mechanisms and management of pollination in autogamous and allogamous crops; genetic constitution of varieties, hybrids and basic principles in seed production.

UNIT III : Techniques of hybrid seed production - emasculation and crossing: use of self-incompatibility, modification of sex; types of male sterility and exploitation in hybrid development and its use in hybrid seed production; development and maintenance of A, B and R lines.

UNIT IV : Fertility restoration; use of chemical hybridizing agents, problems of non synchrony in flowering of parental lines and methods to overcome; planting ratios and population density in relation to hybrid seed yield; salient features of hybrid seed production of major vegetable crops.

Practical : Methods of hybrid seed production in major agricultural and horticultural crops; planting of rows/blocks of parental lines and manipulations for achieving flowering synchrony for production of hybrid seeds, maintenance of A, B and R lines and production of breeder seed; stable diagnostic characteristics of parental lines and their hybrids; genetic purity tests; determination of cost of hybrid seed production of various crops; visit to seed production plots *etc*.

Suggested 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.

HORTICULTURE PLANT PATHOLOGY

Course No.	Title	Credit hours
	A. CORE COURSE	
HPP 501	Principles of plant pathology	1+1
HPP 502	Mycology	2+1
HPP 503	Plant bacteriology	1+1
HPP 504	Plant nematology	1+1
HPP 505	Plant virology	1+1
HPP 506	Disease resistance in plants	1+1
HPP 507	Integrated disease management	1+1
HPP 508	Plant disease diagnostics	0+1
	Total	**16**
	B. OPTIONAL COURSES (Minimum 4 Credits)	
HPP 509	Diseases of fruits, spices and plantation crops	1+1
HPP 510	Diseases of vegetables, flowers, medicinal and aromatic plants	1+1
HPP 511	Chemicals in plant disease management	1+1
HPP 512	Biological management of plant disease	1+1
HPP 513/ HET 513	Plant quarantine	1+0
HPP 514	Seed pathology	1+1
HPP 515/HET 515	Insect vectors of plant viruses and other pathogens	1+1
HPP 516	Epidemiology and forecasting of plant diseases	1+1
HPP 517	Post harvest pathology	1+1
HPP 518	Mushroom production technology	1+1
HPP 519	Ecology of soil-borne plant pathology	1+1
	Total	**22**

A. CORE COURSES

HPP 501 PRINCIPLES OF PLANT PATHOLOGY (1+1)

Theory

UNIT I : Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

UNIT II : Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

UNIT III : Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

UNIT IV : Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

UNIT V : Disease management strategies.

Practical : Study of growth in fungi and bacteria, inoculatin techniques and proving Koch's postulates. Purification of enzymes, toxins and their bioassay. Estimation of growth regulators, phenolics, Phytoalexins in resistant and susceptible plants. Molecular techniques to study variability in different plant pathogens. Molecular markers related to resistance. Plant transformation techniques. Screening techniques for plant diseases.

Suggested References

Agrios GN. 2005. *Plant Pathology*. 5th Ed. Academic Press, New York.

Chaube H.S. and Ramji Singh, 2001, Introductory Plant Pathology, IBDCO, Lucknow.

Heitefuss R & Williams PH. 1976. *Physiological Plant Pathology*. Springer Verlag, Berlin, NewYork.

Mehrotra RS & Aggarwal A. 2003. *Plant Pathology*. 2nd Ed. Oxford & IBH, New Delhi. Singh RS. 2002. *Introduction to Principles of Plant Pathology*. Oxford & IBH, New Delhi.

Singh DP & Singh A. 2007. *Disease and Insect Resistance in Plants*. Oxford & IBH, New Delhi.

Upadhyay RK & Mukherjee KG. 1997. *Toxins in Plant Disease Development and Evolving Biotechnology*. Oxford & IBH, New Delhi.

Vidhyasekaran, P, 2004, Concise Encyclopedia of Plant Pathology, Viva Books Pvt. Ltd., New Delhi.

Vidhyasekaran, P, 2008, Fungal pathogenesis in plants and crops, Molecular Biology and Host defense mechanisms, 2nd Edition, CRC Press.

HPP 502 MYCOLOGY (2+1)

Theory

UNIT I : Introduction, definition of different terms, basic concepts.

UNIT II : Importance of mycology in agriculture, relation of fungi to human affairs, history of mycology.

UNIT III : Concepts of nomenclature and classification, fungal biodiversity,reproduction in fungi.

UNIT IV : The comparative morphology, Ultrastructure, life cycle and characters of different Phyla of fungi up to generic level: (a) Chytridiomycetes (b) Chromista (c) Zygomycetes (d) Ascomycetes (e) Basidiomycetes.

Practical : Detailed comparative study of different groups of fungi; collection, identification and preservation of specimens. Isolation and identification of plant pathogenic fungi. Study of Life cycles of important plant pathogenic fungi like *Pythium, Phytophthora, Allomyces, Plasmopara, Albugos, Aspergillus, Rhizopus, Claviceps, Erysiphe, Venturia, Pucccinia, Ustilago, Uromyces, Tilletia, Pyricularia, AM fungi.*

Suggested References

Ainsworth GC, Sparrow FK & Susman HS. 1973. *The Fungi- An Advanced Treatise*. Vol. IV (A & B).Academic Press, New York.

Alexopoulos CJ, Mims CW & Blackwell M.2000. *Introductory Mycology* 4th Ed. John Wiley & Sons, New York.

Mehrotra RS & Arneja KR. 1990. *An Introductory Mycology*. Wiley Eastern, New Delhi.

Sarbhoy AK. 2000. *Text book of Mycology*. ICAR, New Delhi.

Singh RS. 1982. *Plant Pathogens – The Fungi*. Oxford & IBH, New Delhi.

Webster J. 1980. *Introduction to Fungi*. 2nd Ed. Cambridge Univ. Press, Cambridge, New York.

HPP 503 PLANT BACTERIOLOGY (1+1)

Theory

UNIT I : History and introduction to phytopathogenic procarya, viz., bacteria, MLOs, spiroplasmas and other fastidious procarya. Importance of phytopathogenic bacteria.

UNIT II : Evolution, classification and nomenclature of phytopathogenic procarya and important diseases caused by them.

UNIT III : Growth, nutrition requirements, reproduction, preservation of bacterial cultures and variability among phytopathogenic procarya.

UNIT IV : General biology of bacteriophages, L form bacteria, plasmids and bdellovibrios.

UNIT V : Procaryotic inhibitors and their mode of action against phytopathogenic bacteria.

UNIT VI : Survival and dissemination of phytopathogenic bacteria.

Practical : Isolation, purification, identification and host inoculation of phytopathogenic bacteria, staining methods, biochemical, serological and molecular characterization, isolation of plasmid and use of antibacterial chemicals/antibiotics.

Suggested References

David .C. Sigee, 1993, Bacterial Plant Pathology, Cambridge Publication.

Goto M. 1990. *Fundamentals of Plant Bacteriology*. Academic Press, New York.

Janes. J.D. ., Phytobacteriology, 2005, Principles and practices CAB, Publication.

Jayaraman J & Verma JP. 2002. *Fundamentals of Plant Bacteriology*. Kalyani Publ., Ludhiana.

Mount MS & Lacy GH. 1982. *Phytopathogenic Prokaryotes*. Vols. I, II. Academic Press, New York.

Verma JP. 1998. *The Bacteria*. Malhotra Publ. House, New Delhi.

Verma JP, Varma A & Kumar D. (Eds). 1995. *Detection of Plant Pathogens and their Management*. Angkor Publ., New Delhi.

HPP 504 PLANT NEMATOLOGY (1+1)

Theory :UNIT I: Introduction. Economic importance of nematodes; History and growth of nematology;

UNIT II: Gross morpho-anatomy of nematodes; biology of plant parasitic nematodes; Broad classification; Parasitism, nature of damage and general symptomatology; Interaction of nematodes with other organisms.

UNIT III Occurrence, symptoms, on important crops, cellular responses to infection, physiologic specialization/ variation, ecology, broad management measures in respect of root knot nema, cyst nema, seed gall nema, reniform nema, citrus nema, lesion nema, burrowing nema, stem and bulb nema, ectoparasitic nema, dagger nema and foliar nematodes.

Practicals : Collection of soil and plant samples. Extraction of nematodes from soil by Baermann funnel and sieving and decanting methods. Extraction of cysts from soil. Staining plant material for nema; Killing and fixing of nema; Preparation of temporary and permanent mounts, Perineal pattern and cone top preparation, Plant disease symptoms due to nema; Identification of genera, *viz*. root knot, cyst, lesion, burrowing, reniform and seed gall, nematodes, ectoparasities; Application of nematicides; seed and seedling treatment.

Suggested References

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

Dropkin VH. 1980. *An Introduction to Plant Nematology*. John Wiley &Sons, New York.

Maggenti A R. 1981. General Nematology. Springer- Verlag, New York

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

Ravichandran N G., *Plant Nematology* , I K., International Publication : India

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

Upadhyaya RK, Walia RK and Dubey OP. 2004. IPM Systems in Agriculture. Vol. IX. Phytonematology. Aditya Books, New Delhi.

HPP 505 PLANT VIROLOGY (1+1)

Theory

UNIT I : History of plant viruses, origin and evolution, composition and structure of viruses.

UNIT II : Symptomatology of important plant viral diseases, transmission, chemicaland physical properties, host virus interaction, virus vector relationship.

UNIT III : Virus nomenclature and classification, genome organization, replication and movement of viruses.

UNIT IV : Isolation and purification, electron microscopy, protein and nucleic acid based diagnostics.

UNIT V : Myco viruses, Phytoplasma arbo and baculoviruses, satellite viruses, satellite RNAs, phages, viroids, prions. Principles of the working of electron-microscope and ultra-microtome.

UNIT VI : Origin and evolution, mechanism of resistance, genetic engineering,ecology, and management of plant viruses.

Practical : Study of symptoms caused by viruses, transmission, assay of viruses, physical properties, purification, method of raising antisera, serological tests, electron microscopy and ultratomy, PCR and other nucleic acid based techniques.

Suggested References

Bos L. 1964. *Symptoms of Virus Diseases in Plants*. Oxford & IBH., New Delhi.

Brunt AA, Krabtree K, Dallwitz MJ, Gibbs AJ & Watson L. 1995. *Virus of Plants: Descriptions and Lists from VIDE Database*. CABI, Wallington.

Gibbs A & Harrison B. 1976. *Plant Virology - The Principles*. Edward Arnold, London.

Hull R. 2002. *Mathew's Plant Virology*. 4th Ed. Academic Press, New York.

Mandahar, C.L., 1987; Introduction to Plant Viruses, Chandand Company (pvt) Ltd., 586 pp.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Oxford & IBH, New Delhi.

Singh, R.S., 1989, Plant Pathogens: The Viruses. Oxford and IBH publishing Co., Pvt. Ltd., New Delhi.216 pp.

HPP506 DISEASE RESISTANCE IN PLANTS (1+1)

Theory

UNIT I : Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centers as sources of resistance, disease resistance terminology.

UNIT II :Disease escapes, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease

progression in relation to resistance, stabilizing selection pressure in plant pathogens.

UNIT III : Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms.

UNIT IV : Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

Practical : Study of various plant morphological structures associated with resistance, testing the effect of root exudates and extracts on spore germination and growth of plant pathogens. Estimating the phenolic substances, total reducing sugars in susceptible and resistant plants. Estimating the rhizosphere and root tissue population of microorganisms (pathogens) in plants.

Suggested References

Deverall BJ. 1977. *Defense 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. KalyaniPubl., 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.

HPP 507 INTEGRATED DISEASE MANAGEMENT (1+1)

Theory

UNIT I : Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications.

UNIT II : Development of IDM- basic principles, biological, chemical and cultural disease management and host plant resistance.

UNIT III :IDM in important crops like tomato, potato, chilli, cruciferes, cucurbits, mango, pomegranate, grapes, banana, citrus, arecanut, coconut, betel vine, black pepper, cardamom, coffee, rose, tube rose and jasmine.

Practical : Application of cultural, chemical and biocontrol agents, their compatibility integration in IDM; demonstration of IDM in certain crops as project work.

Suggested References

Biotechnological Approaches for the Integrated Management of Crop Diseases. Daya Publ. House, New Delhi.

Ciancio, A and Mukerji K.G., 2007, General concepts in Integrated Pest and Disease Management Springer Publication. N.Y.

Gupta VK & Sharma RC. (Eds). 1995. *Integrated Disease Management and Plant Health*. Scientific Publ., Jodhpur.

Mayee CD, Manoharachary C, Tilak KVBR, Mukadam DS & Deshpande Jayashree (Eds.). 2004.

Sharma R.C. and Sharma. J. N. 2005, Integrated Plant Disease Management. Scientific Publishers, New Delhi, India.

HPP 508 PLANT DISEASE DIAGNOSTICS (0+1)

Practical

UNIT I : Isolation and pure culture techniques, use of selective and enriched media, use of selective and enriched media to isolate pathogens.

UNIT II : Microscopic techniques and staining methods, phase contrast system,chromatography, use of electron microscope, spectrophotometer,ultra centrifuge and electrophoretic apparatus, disease diagnostics, serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides, bactericides etc; field experiments, data collection and preparation of references.

Suggested References

Baudoin ABAM, Hooper GR, Mathre DE & Carroll RB. 1990. *Laboratory Exercises in Plant Pathology: An Instructional Kit*. Scientific Publ., Jodhpur.

Dhingra OD & Sinclair JB. 1986. *Basic Plant Pathology Methods*. CRC Press, London, Tokyo.

Chakravarti BP. 2005. *Methods of Bacterial Plant Pathology*. Agrotech, Udaipur.

Mathews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Boca Raton, Tokyo.

Fox RTV. 1993. *Principles of Diagnostic Techniques in Plant Pathology*. CABI Wallington.

Forster D & Taylor SC. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic Resistance*. *Methods in Molecular Biology*. Humana Press, Totowa, New Jersey.

Lakhdar Lawari, 2008, Image Analysis software for Plant Disease Quantification. C.D and manual, APS, Press, USA.

Matthews REF. 1993. *Diagnosis of Plant Virus Diseases*. CRC Press, Florida.

Noordam D. 1973. *Identification of Plant Viruses, Methods and Experiments*. Cent. Agic. Pub. Doc. Wageningen.

Pathak VN. 1984. *Laboratory Manual of Plant Pathology*. Oxford & IBH, New Delhi.

Trigiano RN, Windham MT & Windham AS. 2004. *Plant Pathology-Concepts and Laboratory Exercises*. CRC Press, Florida.

Narayanswamy P., 2001, Plant Pathogen Detection and Disease Diagnosis. 2nd Edition. Marcel Dekkar, New York.

B. OPTIONAL COURSES

HPP 509 DISEASES OF FRUITS, SPICES AND PLANTATION CROPS (1+1)

Theory

UNIT I : Introduction, symptoms, etiology, epidemiology and management of different fruit crops like banana, citrus, mango, grapes, guava, sapota, fig, pineapple, pomegranate, papaya, ber and apple.

UNIT II :Introduction, symptoms, etiology, epidemiology and management of different spice crops like black pepper, cardamom, coriander, ginger, turmeric and others.

UNIT III :Symptoms, mode of perpetuation and management of plantation crops such as tea, coffee, rubber, coconut, arecanut, oil palm, cocoa and betel vine.

Practical : Detailed study of symptoms and host parasite relationship of representative diseases of fruit, spices and plantation crops. Collection and dry preservation of diseased specimens of important crops.

Suggested References

Gupta, V. K., and.Sharma SK. 2000. *Diseases of Fruit Crops*. Kalyani Publ.,New Delhi.

Pathak VN. 1980. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.

Singh RS. 2000. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.

Walker JC. 2004. *Diseases of Vegetable Crops*. TTPP, India.

Agrios G.N. 2005, Plant Pathology, 5th Edition, Academic Press.

Gupta, S. K., and Thind, T. S., 2006, Disease problems in vegetable production, Scientific publishers (India), Jodhpur.

Thind, T. S., 2005 Diseases of fruits and vegetables and their management, Kalyani publishers

Gupta, V. K., and Paul, Y. S., 2001, Diseases of vegetable crops, Kalyani publishers

Singh R. S., 2005, Plant diseases 8th Edition Oxford & IBH publishing co. Pvt. Ltd. New Delhi

HPP 510 DISEASES OF VEGETABLES, FLOWERS, MEDICINAL AND AROMATIC PLANTS (1+1)

Theory

UNIT I : Symptoms, mode of perpetuation of diseases of vegetable crops such as root, bulb, leafy vegetable and solanaceous crops, cucurbits, bhendi, onion, garlic, beans, peas and carrot.

UNIT II : Symptoms and disease cycle of pathogens, factors affecting disease development of ornamental plants such as jasmine, roses, gladiolus, china aster, carnation, tube rose, orchids, marigold, chrysanthemum and anthurium and their management.

UNIT III : Symptoms, epidemiology and management of diseases of different medicinal and aromatic crops such as periwinkle, basal, coleus, stevia, ashwagandha, vetiver, citronella, geranium, patchouli and others.

Practical : Detailed study of symptoms and host pathogen interaction of important diseases of vegetables, flowers, medicinal and aromatic crops.

Suggested References

Janardhanan, 2002, Diseases of major medicinal crops. Daya publications, Lucknow.

Singh R. S., 2005, Plant diseases 8th Edition Oxford & IBH publishing co. Pvt. Ltd. New Delhi.

Kulkarni, S and Hegde, Y. R., 2002, Diseases of plantation crops and their management. Agrotech publishing academy.

Jahagirdar, S, Ravi Kumar, M. R. and Kulkarni, S., 2005, Diseases of fruits and plantation crops and their management: A modern perspective.

HPP 511 CHEMICALS IN PLANT DISEASE MANAGEMENT (1+1)

Theory

UNIT I : History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals.

UNIT II : Classification of chemicals used in plant disease control and their characteristics.

UNIT III : Chemicals in plant disease control, *viz.,* fungicides, bactericides, nematicides, antiviral chemicals and botanicals.

UNIT IV : Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides.

UNIT V : Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides.

UNIT VI : General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

Practical : Acquaintance with formulation of different fungicides and plant protection appliances. Formulation of fungicides, bactericides and nematicides; *invitro* evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides based on active ingredients against pathogens; persistence, compatibility with other agro-chemicals; detection of naturally occurring fungicide resistant mutants of pathogen; methods of application of chemicals.

Suggested References

Bindra OS & Singh H. 1977. *Pesticides - An Application Equipment*. Oxford & IBH, New Delhi.

Torgeson DC (Ed.). 1969. *Fungicides*. Vol. II. *An Advanced Treatise*. Academic Press, New York.

Vyas SC. 1993. *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

HPP 512 BIOLOGICAL MANAGEMENT OF PLANT DISEASES (1+1)

Theory

UNIT I : Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological management.

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

UNIT III : 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 of different bioagents.

UNIT IV : Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents.

Practical : Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen *in vitro and in vivo* conditions. Study of cfu/g.

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.

Nene YL & Thapliyal PN. 1993. *Fungicides in Plant Disease Control.* 3rd Ed. Oxford & IBH, New Delhi.

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 513/HET 513 PLANT QUARANTINE (2+0)

Theory

UNIT I : Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

UNIT II : Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

UNIT III : Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestation/salvaging of infected material.

UNIT IV : WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures. Inspection procedures for import/export of plant material for research purposes at the point of enrty/export stations, detection techniques for various plant pathogens. Treatment procedures and chemicals. Hints for researchers to import/export of plant genetic material.

Suggested References

Maude, R.B. 1996, Seed Borne Diseases and Their control- Principles and practice. CAB International, UK.

Rajeev, K, and Mukherjee, R. C. 1996. Role of Plant Quarantine in IPM. Aditya Books.

Rhower GG. 1991. Regulatory Plant Pest Management. In: Handbook of Pest Management in Agriculture. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

HPP 514 SEED PATHOLOGY (1+1)

Theory

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

UNIT II : Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

UNIT III : Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.

UNIT IV : Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogen/diseases and procedure for healthy seed production, seed health testing, methods for detecting microorganism.

Practical : Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses. 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 515/ HET 515 INSECT VECTORS OF PLANT VIRUSES AND OTHER PATHOGENS (1+1)

UNIT I : History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.

UNIT II : Transmission of plant viruses by fungi, nematodes. Relation between viruses and their vectors.

UNIT III : Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.

UNIT IV : Transmission of phytoplasma and Fastidious vascular bacteria by leaf hoppers and plant hoppers.

UNIT V : Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

Practical : Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies.

Suggested References

Basu AN. 1995. *Bemisia tabaci (*Gennadius*) - Crop Pest and Principal Whitefly Vector of Plant Viruses.* Oxford & IBH, New Delhi.

Harris KF & Maramarosh K. (Eds.).1980. *Vectors of Plant Pathogens*. Academic Press, London.

Maramorosch K & Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.

Youdeovei A & Service MW. 1983. *Pest and Vector Management in the Tropics*. English Language Books Series, Longman, London.

HPP 516 EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES (1+1)

Theory

UNIT I

Epidemic concept and historical development, pathometry and crop growth stages, epidemic growth and analysis, systems approach in epidemiology

UNIT II : 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, Epidemic avoidance.

UNIT III : Survey, surveillance and vigilance, crop loss assessment and models.

UNIT IV : Principles and pre-requisites of forecasting, systems and factors affecting various components of forecastings, some early forecasting, procedures based on weather and inoculum potential, modeling disease growth and disease prediction.

Practical : Measuring diseases, spore dispersal and trapping, weather recording, survey, multiplication of inoculum, 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 517 POST HARVEST PATHOLOGY (1+1)

Theory

UNIT I : Concept of post harvest diseases, definitions, importance with reference to environment and health, principles of plant disease management as pre-harvest and post-harvest, merits and demerits of biological/ phytoextracts in controlling

post-harvest diseases., Health hazards due to post harvest diseases, Mycotoxins – types, effect on human and animal health prevention.

UNIT II : Study of Post harvest diseases of mango, banana, citrus, papaya, grapes and important vegetable crops like tomato, potato, leafy vegetables, onion, carrot, cabbage and gourds, their microbial spoilage and strategies for post harvest management. Types of post harvest problems both by biotic and abiotic causes, rhizosphere colonization, competitive, saprophytic ability, antibiosis, induced resistance, microbial associations, concept, operational mechanisms and its relevance in control.

UNIT III : Factors governing post harvest problems both as biotic and abiotic, role of physical environment, agro-ecocystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists. Isolation, characterization and maintenance of pathogens, role of different storage.

UNIT IV : Integrated approach in controlling diseases and improving the shelf life of produce, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for any health hazard, knowledge of Codex Alimentarious for each product and commodity.

Practical : Isolation, characterization and maintenance of pathogens, role of different storage conditions on disease development, application of antagonists against pathogens *in vivo* and *in vitro* conditions. Comparative efficacy of different chemicals, fungicides, phytoextracts and bioagents.

Suggested References

Snowdon, A. L., 1991, A colour Atlas of Post harvest diseases and disorder of fruits and vegetables. Vol.I and Vol.II, Wolfe scientific ltd.

Dasgupta, M.K. and Mandal, N.C. 1989, Post harvest pathology of perishables Oxford and IBH publishing co. Pvt. Ltd.,

Dennis., C., 1983, Post harvest Pathology of frits and vegetables.

Sharma, N and Mashkoor, M., 1998, Post harvest diseases of horticultural perishables.

Pathak VN. 1970. *Diseases of Fruit Crops and their Control*. IBH Publ., New Delhi. Chaddha KL & Pareek OP. 1992. *Advances in Horticulture* Vol. IV, Malhotra Publ. House, New Delhi.

HPP 518 MUSHROOM PRODUCTION TECHNOLOGY (1+1)

Theory

UNIT I : Historical development of mushroom cultivation and present status, taxonomy, classification, food, medicinal value, uses of mushroom, edible and poisonous mushrooms.

UNIT II : Biology and life cycle of cultivated mushrooms, reproduction and strain improvement, maintenance of pure culture, preparation of spawn and facilities required for establishing commercial spawn lab.

UNIT III : Preparation of substrate for mushroom cultivation, long, short and indoor composting methods, formulae for different composts and their computation, qualities and testing of compost, uses of spent mushroom compost/substrate.

UNIT IV : Facilities for setting up mushroom farm for seasonal and environmentally controlled cultivation, requirement and maintenance of temperature, relative humidity, CO_2, ventilation in cropping rooms, cultivation technology of *Agaricus bisporus, Pleurotus* sp.*, Calocybe indica, Lentinus edodes* and *Ganoderma lucidum.*

UNIT V : Insect pests, diseases and abnormalities of cultivated mushroom and their management, post harvest processing and value addition, economics of mushroom cultivation, biotechnology and mushroom cultivation.

Practical : Preparation of spawn, compost, spawning, casing, harvesting and post-harvest handling of edible mushroom; identification of various pathogens, competitors of various mushroom.

Suggested References

Chadha KL & Sharma SR. 2001. *Advances in Horticulture* (*Mushroom*). Vol. XIII. Malhotra Publ.House, New Delhi.

Chang ST & Hays WA. 1997. *The Biology and Cultivation of Edible Mushrooms*,Academic Press, New York.

Chang ST & Miles PG. 2002. *Edible Mushrooms and their Cultivation*. CRC Press, Florida.

Kapur JN. 1989. *Mushroom Cultivation*. DIPA, ICAR, New Delhi.

Dhar BL. 2005. *Cultivation Technology of High Temperature Tolerant White Button Mushroom*. DIPA, ICAR, New Delhi.

HPP 519 ECOLOGY OF SOIL-BORNE PLANT PATHOGENS (1+1)

Theory

UNIT I : Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Types of biocontrol agents.

UNIT II : Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis.

UNIT III : Suppressive soils, biological control-concepts and potentialities for managing soil borne pathogens.

Practical : Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens; pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils; suppression of test soil-borne pathogens by antagonistic microorganisms. Isolation and identification of different biocontrol agents.

Suggested References

Baker KF & Snyder WC. 1965. *Ecology of Soil-borne Plant Pathogens*. John Wiley, New York.

Cook RJ & Baker KF. 1983. *The Nature and Practice of Biological Control of Plant Pathogens*. APS, St Paul, Minnesota.

Garret SD. 1970. *Pathogenic Root-infecting Fungi*. Cambridge Univ. Press, Cambridge, New York.

Hillocks RJ & Waller JM. 1997. *Soil-borne Diseases of Tropical Crops*. CABI, Wallington.

Parker CA, Rovira AD, Moore KJ & Wong PTN. (Eds). 1983. *Ecology and Management of Soil-borne Plant Pathogens*. APS, St. Paul, Minnesota.

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

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- New York Academic Press

e-Resources:

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 Master's Research

Pathogenesis and characterization of plant pathogens

Survey and surveillance

Induction of resistance using biotic and abiotic elicitors

Variability in plant pathogens

Plant-Virus-Vector relationships

Genome organization of plant pathogens

Dynamics of plant pathogen propagules and their biology

Molecular tools in disease diagnosis

Molecular mechanisms of pathogenesis in crops and seeds

Rhizosphere in pathogenesis of seed-borne plant pathogens

Transgenic resistance

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

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ENTOMOLOGY

Code	A. Core Courses	Credits
HET 501	Insect Morphology	1 + 1
HET 502	Insect Anatomy and Physiology	1 +1
HET 503	Insect Systematics	1 + 1
HET 504	Toxicology of Insecticides	1 + 1
HET 505	Pests of Fruit and Plantation crops	1 + 1
HET 506	Pests of Vegetable and Ornamental crops	1 + 1
HET 507	Pests of Spices, Medicinal and Aromatic crops	1 + 1
HET 508	Insect Ecology	1+ 1
	Total	**16**
	B. Optional Courses (minimum 4 credits)	
HET 509	Principles of Integrated Pest Management	1 + 1
HET 510	Biological Panagement of Pests and Weeds	1 + 1
HET 511	Postharvest Entomology	1 + 1
HET 512	General Acarology and Araneology	1 + 1
HET 513	Insect Vectors of Plant Pathogens	1 + 1
HET 514	Research Techniques in Entomology	0 + 1
HET 515	Plant Quarantine Measures	2+0
HET 516	Application of Biotechnology in Pest Management	1 + 1
HET 517	Insect Pathology	1 + 1
HET 518	Plant Resistance to Insects	1 + 1
HET 519	Soil Arthropods and their Management	1 + 1
HET 520	Vermiculture and Vermicomposting	1 + 1
HET 521	Vertebrate Pest Management	1 + 1
HET 522	Forest Entomology	1 + 1
HET 523	Economic Entomology	1 + 1
HET 524	Pests of Horticultural crops	2+1
HET 525	Applied Apiculture	1+1
	Total	**34**

A. CORE COURSES

HET 501 INSECT MORPHOLOGY (1+1)

Theory : Principles, utility and relevance. Integument- structure, colours, outgrowths, appendages, functions. Head- origin, definitive insect head, appendages, antennae, mouthparts and modifications, tentorium, neck-sclerites. Thorax - sclerites, sutures, ridges, areas of tergum, sternum and pleuron, pterothorax, their modifications, wings-origin, structure, modifications, venation, articulation, wing coupling, legs-structure, articulation, modifications. Abdomen- sclerites, pregenital, genital segments, appendages, genitalia, modifications. Embryology and Development.

Practical : Preparation of permanent and temporary mounts slides. Integument outgrowths. General morphology of grasshopper. Head- sclerites, sutures, areas, types, tentorium , types of antenna, mouthparts and their modifications, grasshopper, honey bee, red cotton bug, thrips, butterfly, house fly, caterpillar. Thorax- sclerites, wings-types and venation, wing coupling. Legs- types. Abdomen,- stinging organ in bees and wasps, genitalia, post embryonic development.

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

Suggested Reference

Snodgrass, R. E., 1935, *Principles of Insect Morphology.* MacGraw-Hill Book Co., New York.

Charles, A., Triplehorn and Norman F. Johnson, 2008, *Borror and De Long's Introduction to the study of Insects.* Thomson Books/Cole, US. P. 864.

Chapman, R. F., 1998, *The Insects structure and Function.* Cambridge University Press. P. 770.

Metcalf, C. L. and Flint, W. P., 1990, *Fundamentals of insect life.* Low Price Publications, Delhi. P. 581.

Richards, O. W. and Davies, R. G., 1984, *Imm's General Textbook of Entomology, Vol. II Classification and Biology.* Chapman and Hall, London.

Richards, O. W. and Davies, R. G., 1984, *Imm's General Textbook of Entomology, Vol. I Structure, Physiology and Development.* Chapman and Hall, London. P. 418

HET 502 INSECT ANATOMY AND PHYSIOLOGY (1+1)

Theory : Importance and Scope. Physiology of sensory organs. Muscle excitation. Structure, modification and physiology of various systems; digestive, circulatory, excretory, respiratory, nervous and reproductive. Types of reproduction. Integument and ecdysis, Digestive system and Insect Nutrition, Circulatory system -haemocytes and their functions. Tracheal system - Exchange of gases, modifications in aquatic insects. Excretory system - excretion in terrestrial and aquatic insects. Nervous system - CNS and peripheral NS, Neurons and nerve impulse transmission Brain, ganglia and synapses, Photoreceptors, mechanoreceptors, chemoreceptor, thermo and hygroreceptors. Reproductive system: Male and female reproductive systems, spermatogenesis, oogenessis, types of reproduction, Parthenogenesis, Polyembryoni, Paedogenesis. Integument and moulting. Structure and function of endocrine organs and hormones. Biological rhythms and diapause.

Practical : Dissection and display of digestive, circulatory, respiratory, excretory, nervous and reproductive systems in different groups of insects. Study of endocrine glands, blood cells, symbiotic microorganisms. Estimation of chitin in cuticle, amino acids in haemolymph. Simple physiological experiments on digestion, respiration, excretion, Purification and evaluation of juvenile hormones.

Suggested Reference

Beament, J. W. L., Treherne, J. E. And Wigglesworth, V. B., 1968, *Advances in Insect Physiology.* Academic Press, London. P. 357.

Chapman, R. F., 1998, *The insects structure and Function.* Cambridge University Press. P. 770.

Gullan P.J., and Cranston P.S., 2000, The Insects An outline of Entomoloy. Blackwell Science P.470.

Richards, O. W. and Davies, R. G., 1984, *Imm's General Textbook of Entomology, Vol. I Structure, Physiology and Development.* Chapman and Hall, London. P. 418.

HET 503 INSECT SYSTEMATICS (1+1)

Theory : Importance of study of insect systematics and study of immature insects. Definition of systematics and taxonomy, zoological nomenclature; binomial nomenclature, Linnaeus contribution. Important rules, homonyms and synonyms, International Code of Zoological Nomenclature. Taxonomic hierarchy. Importance of taxa and its categories, keys in identifying taxa. Diagnostic characters of class Hexapoda. Systems of classification, phylogeny of insects and interrelationships, immature and adult diagnostic characters of Protura, Collembola, Diplura, Thysanura, Microcoryphia, Ephemeroptera, Odonata, Grylloblattodea, Phasmida, Orthoptera, Different families of Orthoptera, their economic importance, habits and habitats. Diagnostic characters of Mantodea, Blattaria, Isoptera, Dermaptera, Mantophasmatodea, Embioptera, Plecoptera, Zoraptera, Psocoptera, Anoplura. Mallophaga, Hemiptera, Homoptera, Thysanoptera, Neuroptera, detailed studies on Neuropteran family! families occuning in India. Coleoptera, up to family level, Strepsiptera and Mecoptera. Trichoptera, MegalopteraSiphonaptera, Diptera, Lepidoptera. Classification of Lepidoptera and Diptera up to family level, including larvae. Hymenoptera-Characters and classification up to family level.

Practical : Techniques of collection, pinning, setting *etc*., Visit to various habitats for collections. Study of insect eggs. Identification of different nymphs by using keys. Types of larvae and pupae and their identification. Identification of different insect adults covering all orders by using keys. Collection of insects belonging to representative families. Visit to nearby ecosystems for collection of Insects.

Suggested Reference

Charles, A., Triplehorn and Norman F. Johnson, 2005, *Borror and De Long's Introduction to the study of Insects.* Thomson Books/Cole, US. P. 864.

Richards, O. W. and Davies, R. G., 1984, *Imm's General Textbook of Entomology, Vol. II Classification and Biology.* Chapman and Hall, London.

Snodgrass, R. E., 1935, *Principles of Insect Morphology.* MacGraw-Hill Book Co., New York.

Kapoor, V. C., 1983, *Theory and Practice in Animal Taxonomy.* Oxford and IBH, New Delhi.

Mayr, E., 1971, *Principles of Systematic Zoology.* Tata McGraw-Hill, New Delhi

HET.504 TOXICOLOGY OF INSECTICIDES (1+1)

Theory : History and importance of chemical control. Types of pesticides - insecticides, acaricides, rodenticides and molluscicides. Principles of toxicology- Sigmoid curve, dosage mortality relationship, regression coefficient. Probit analysis. Determination of acute toxicity. Insecticides: formulations, types of formulation. Classification of insecticides based on chemical nature: Orgamochlorines, OP Compounds, carbamates, pyrethroids formamidines, neonicotinoids, nerves toxins, IGR, chitin intibitors, microbial insecticides and new molecules. Insecticide act and rule, registration of insecticides. Insecticide resistance -development, factors affecting and management. Sprayers, dusters and other appliances use and their maintenance.

Practical : Study of properties of insecticides. Insecticide formulations. Bioassy - methods of administration, - determination of lethal doses concentration and time. Resistance monitoring and insecticide residue analysis, calculation, preparation and application of spray mixture. Use of safety devices. Visit to insecticide dust formulation units and fumigation godowns.

Suggested Reference

Soloneski, S., and Larramendy, M., 2014, Insecticides: Basics and other applications Tech. Pub.

Tomlin, Clieve, 1995, *A world compendium the pesticide manual- incorporating the agrochemicals handbook.* Crop Protection Publications. P. 1341.

Vasantharaj David, B., 2002, *Elements of Economic Entomology.* Popular Book Depot., Chennai.

Promod, P. Mahulikar and Kshama, M. Chavan, 2007, *Botanicals as Ecofriendly Pesticides*. New India Publishing Agency. P. 264.

Gupta, H. C. L., 1999, *Insecticides: Toxicology and Uses.* Agrotech Publ., Udaipur.

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

Paranjape, K., Gowariker, V, Krishnamurthy V.N., and Gowariker, S., 2015, The Pesicide Encydopedia, CABI Publishing.

HET 505 PESTS OF FRUITS AND PLANTATION CROPS (1+1)

Theory : Pest status, distribution, bioecology, economic threshold level and management strategies for important insect and mite pests of fruit crops -

mango, guava, citrus, banana, sapota, grapes, pomegranate, papaya, litchi, datepalm, jamun, custardapple, melon, ber, fig, jack fruit, pineapple. Plantation crops - coconut, arecanut, coffee, tea, cashew, cocoa and rubber.

Practical : Collection of 50 major horticultural crop pests. Study of damage symptoms and nature of damage of the pests of above crops. Rearing of five horticultural crop pests and preserving their developmental stages. Visit to research stations / farmers fields.

Suggested Reference

Afwal, A.S., and Dhaliwal, G.S., 2008, Agricultural Pests of south Asia and their management Kalyani. Pub.

Nayar, K. K., Ananthakrishna, T. N. and David, B. V., 1998, *General and Applied Entomology*. Tata McGraw-Hill Publishing Company Ltd., New Delhi. P. 589.

Nair, M. R. G. K., 1995, *Insects and mites of crops to India.* ICAR, New Delhi.

Frayer, J. C. F., *Insect Pests of Fuit Crops.* Biotech book, Delhi.

HET 506 PESTS OF VEGETABLE AND ORNAMENTAL CROPS (1+1)

Theory : Pest status, distribution, bioecology, economic threshold level and management strategies for important insect and mite pests of Vegetables – tomato, potato, brinjal, chillies, cucurbits, cruciferous vegetables, bhendi, drumstick, onion, green chilli, sweet potato, beans, peas and leafy vegetables. Ornamental plants - rose, carnation, chinaaster, orchids, anthurium, chrysanthemum, tuberose, jasmine, crosandra, gerbera, marigold, gladiolus *etc.*

Practical : Collection of 50 insect pests of above mentioned crops. Study of symptoms and nature of damage of the pests of above crops. Rearing of five crop pests and preserving their developmental stages. Visit to research stations / farmers fields.

Suggested Reference

Parvathareddy, P., 2010, Insect mite and vertabrate pests and their management in Horticultural crops, scientific Pub.

Parvath Reddy, P., Abraham Verghese and Krishnakumar, N. K., 2001, *Integrated Pest Management in Horticultural Ecosystems.* Capital Publishing Company, New Delhi. P. 292.

Srivastava, K. P. and Dhama, K. Butani, 2009, Pest management in vegetables. *Studium Press* (India) Pvt. Ltd. P. 381.

Srivastava, K. P. and Dhamo, K. Butani, 1998, *Pest Management in vegetables part I.* Research Periodicals and Book Publishing House, USA. P. 589.

Srivastava, K. P. and Dhamo, K. Butani, 1998, *Pest Management in vegetables part II.* Research Periodicals and Book Publishing House, USA. P. 589.

David, V. Alford, 1991, *Pests of ornamental trees, shrubs and flowers*

HET 507 PESTS OF SPICES, MEDICINAL AND AROMATIC CROPS (1+1)

Theory : Pest status, distribution, bioecology, economic threshold level and management strategies for important insect and mite pests of Spices - cardamom, pepper, coriander, ginger, turmeric, cinnamon, vanilla, curry leaves, clove, nutmeg, cumin, mint, garlic and chilli. Pests of medicinal and aromatic crops- solanum, ashwagandha, coleus, isabagol, vinca, opium, sarphagandha and pests of major aromatic plants- jasmine, mint, patchouli, French basil, lemon grass and davana.

Practical : Collection of 50 insect pests of above mentioned crops. Study of symptoms and nature of damage of the pests of above crops. Rearing of five crop pests and preserving their developmental stages. Visit to research stations / farmers fields.

Suggested Reference

Panwar, V. P. S., 2002, *Agricultural insect pests of crops and their control.* Kalyani publishers, Cuttack. 0. 286.

Kumaresan, D., Regupathy, A. and Baskran, P., 1988, *Pests of Spices.* Rajalakshmi Publications, Nagercoil.

Parvath Reddy, P., Abraham Verghese and Krishnakumar, N. K., 2001, *Integrated Pest Management in Horticultural Ecosystems.* Capital Publishing Company, New Delhi. P. 292.

HET 508 INSECT ECOLOGY (1+1)

Theory: Basic concepts of ecology. Components of environment. Effect of environmental factors on life cycle, behaviour, distribution and abundance of insects. Population regulation - natural control and current theories. Characteristics of population. Biotic potential and environmental resistance. Stable age distribution. Population dynamics, Life tables Food chain and ecological succession. Dispersal and migaration. Tropism and kinesis. Diapause, hibernation and aestivation. Ecological indicators.

Practical : Measurement of micro-environment. Estimation of thermal requirement. Concepts of life table and construction of life tables. Measurement of biodiversity. Computer simulation modeling. Estimates of population density. Sampling methods and plans. Estimation of dispersion and migration.

Suggested Reference

Nigel, E. Stork, 1990, *The role of Ground beetle in Ecological and Environmental studies*. Intercept Andover, Hampshire. P. 424.

William, S., Romoser and John, G., Staffolano Jr., 1994, *The Science of Entomology.* Wm. C. Brown Publishers, England. P. 532.

Gullan, P. J. and Cranston, P. S., 2014, *The Insects- An outline of Entomology.* Blackwell Science. P. 470.

Rajiv, K., Gupta, 2007, *Advancement in insect biodiversity*. Agrobios (India). P. 324.

Eugene, P. Odum, 1971, *Fundamentals of Ecology*. Nataraj Publishers, Dehra Dun. P. 574.

Chapman, J. L. and Reiss, M. J., 1995, *Ecology-Principles and applications*. Cambridge Unviersity Press. P. 294.

Peter, W. Price, Denno R.F., Eubank, M.D., Finke D.L., and Kaplan, I 2013, *Insect Ecology: Behaerous, populations and communities., cambridge Pub.*

Timothy, D. Schowalter, 2000, *Insect Ecology – An Ecosystem Approach.* Academic Press. P 483

Pedigo L.P., abd Rice, M.E., 2009, entomology and Pest Management 6th Edn, Pearson Prentice Hall.

B. OPTIONAL COURSES

HET 509 PRINCIPLES OF INTEGRATED PEST MANAGEMENT (1+1)

Theory : History, purpose and scope of new approach in pest management. Need for integrated control concept. Basic Principles in IPM. Prediction of population trends-Thresholds; i.e. visual and economics. Methods of pest management and economics. Use of tools such as chemosterilants pheromones, Hormones, Feeding deterants, feeding, mating and oviposition stimulants. Chemical attractants, Repellants, their role in Integrated pest Management. Antimetabolites and their role in Integrated Pest Management. Development of autocidal control. Application of sterility principles. Characteristics of the species to be controlled. Irradiation as a method of new tool and its utilization techniques in Integrated Pest Management. Systems of models in IPM General manipulation in IPM. Intefeedants, principles of biocontrol in IPM, Bio technology-transgenic crops and their integration in IPM. Insecticides and their application techniques in IPM. Problems and prospectives of IPM strategies developed for agricultural and horticultural crops.

Practical : Testing of IPM tools under laboratory and field conditions. Experiment s on Integrated Pest Management in different crops. Economics of Integrated Pest Management. Working out ETL, EIL for different pests. Test plots. case studies, surveys, conducting small experiments.

Suggested Reference

Dhaliwal, G. S. and Ramesh Arora, 1998, Principles of insect pest management. Kalyani Publishers, Cuttack. P. 297.

Rama Prakash Srivastava, 2003, *Biopesticides and Bioagents in Integrated Pest Management of Agricultural Crops*. International Book Distributing Co. P. 860.

Larramendy, M.L., and Soloneski, S., 2014, Integrated Pest Management and Pest Control, Current and Future tactics, In Tech, Croatia.

Srivastava, K. P., 1996, A text book of Applied Entomology (Agricultural, Veterinary, Medical, Industrial, Forest, Forensic and Nutritional Entomologyl). Kalyani Publishers, Cuttack. P. 321.

Srivastava, K. P., 1996, A text book of Applied Entomology (Methods of insect pest control). Kalyani Publishers, Cuttack. P. 321.

Opender, Koul, Dhaliwal, G. S. And Cuperus, G. W., 2004, Integrated Pest Management. CABI Publishing, UK. P. 329.

Promod, P. Mahulikar and Kshama, M. Chavan, 2007, Botanicals as Ecofriendly Pesticides. New India Publishing Agency. P. 264.

HET 510 BIOLOGICAL MANAGEMENT OF INSECT PESTS AND WEEDS (1+1)

Theory : The philosophy, scope, history and importance of biological control. Theoretical and empirical basis of biological control, parasitism and predatism, phases of parasitism. Important parasitic and predatory groups of insects and insect pathogens. Ecological basis of biological control. Methods of colonization, recovery and evaluation. Introduction, culture, establishment and management of natural enemy population. Biological control of weeds. Role of natural enemies in Integrated Pest Management. Microbial pesticides their mode of action, mass production and formulation Biological control in protected cultivation system.

Practical : Identification of common natural enemies (parasitoids, predators and phytophagous insects) of crop pests and weeds. Rearing of eggs, egg-larval, larval and pupal parasitoids and their laboratory hosts. Rearing of common predators and phytophagous natural enemies of weeds. Field recovery of parasitoids. Culturing and identification of common insect pathogens.

Suggested Reference

Gautham R,D., 2008, Biological Pest Suppression, Westville Pub. House.

Narayanasamy P., 2010, Organic Pest Management: Potentials and applications, Satish Serial Pub.

Patnaik, B. D., 2001, Parasitic Insects. Dominant Publishers and Distributers, New Delhi. P. 358.

Saxena, A. B., 2003, Biological control of insect pests. Anmol Publications Pvt. Ltd. New Delhi, P. 245.

Stock, S.P., Vandenberg, J., Glager, I and Beemare, N., 2009, Inset Pathogens: Molecular approaches and Techniques, CABI Pub.

HET 511 POSTHARVEST ENTOMOLOGY (1+1)

Theory : Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses in

horticultural stored products in India. Scientific and socio-economic factors responsible for losses. Important pests namely insects, mites, rodents, birds and microorganisms associated with stored products and in field condition. Ecology of insect pests of stored commodities with special emphasis on role of moisture, temperature and humidity in safe storage of horticultural commodities. Types of storage structures i.e. improved and modern structures in current usage. Important rodent pests associated with stored products and their management practices. Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Integrated approaches to stored commodities pest management.

Practical : Collection, identification and familiarization with the insects pests of stored commodities, nature of damage, detection of infestation, estimation of losses, determination of moisture content in stored products. Study of storage structures. Demonstration of preventive and curative measures. Treatment of packing materials and their effect on stored products quality. Visit to warehouses and institutions engaged in research or practice.

Suggested Reference

Khader, V., 2004, Textbook on Food Storage and Preservation. Kalyani Pub., New Delhi.

Subramanyam, B. and hagstrum, D. W., 1995, Interrelated Management of Insects in Stored Products. Marcel Dekker, New York.

HET 512 GENERAL ACAROLOGY & ARANEOLOGY (1+1)

Theory: Introduction and history of acarology. General morphology of Acari. Classification of Acari up to family level. Types of damage and Symptoms. Acaricides. Natural enemies of mites. Bionomics and management of mites and tics crops and horticultural crops, stored products, mushrooms and management of mites and ticks of medical and veterinary importance. Introduction to araneology and its relation with other Araneology. Morphology and anatomy of spiders. Classification of spiders. Spiders biology, methods of study, development of spiders. Food of spiders biology methods of study - Development of spiders. Food of spiders Means of obtaining prey. Spiders silk. Types of Web. Nets of spiders. Pairing of spiders. Motherhood of spiders. Aeromatic spiders. Spiders as natural enemies of crop pests web building spiders webbing, types of web and function. Prey selection. Role of web and hunting spiders in management of pests of cereals, commercial crops, fruit crops and others. Poisonous spiders, conservation and mass multiplication of spiders.

Practical : Methods of collection and preservation of mites and ticks. Rearing of phytophagous and predatory mites. Natural enemies of mites. Sampling techniques for mites. Methods of testing pesticides against mites. Morphological characteristics of higher categories of mites and ticks. Mite pests of field and horticultural crops. Mites and ticks of medical and veterinary importance. Visit to Polyhouse. Study of Habitat of spiders. Collection, preservation and methods of study of spiders. Keys to the families. Study of morphology of different orders. Study of biology and feeding potential of spiders on crop pests. Study of types of spider webs ad nature of web building; physical and chemical properties of web silk.

Suggested Reference

Channabasavanna, G. P. and Viraktamath, C. V., 1998, *Progress in Acarology.* Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, p. 160.

Chillar, B. S., Gulati, R. and Bhatnagar, P., 2007, *Agricultural Acarology.* Daya Publ. House, New Delhi.

Gupta, S. K., 1985, *Handbook of Plant Mites of India.* Zoological Survey of India, Calcutta.

HET 513 INSECT VECTORS OF PLANT PATHOGENS (1+1)

Theory : Insects as Vectors of plant diseases, their importance. Mites as vectors. Different pathogens like virus, fungi, bacteria and nematodes transmitted by insects. Infection through pollen injury, contamination, exudates, feeding and ovipositing wounds. Vector - virus relationship, Vector specificity, Beneficial and lethal effects of plant virus on their vectors. Transmission efficiency of vectors. Feeding habits of vectors and dissemination of viruses. Modes of transmission of insect viruses; fungi, bacteria etc. Transmission. Concepts of vector management, ecological aspects of plant disease transmission. Diseases complex with fungal, bacterial, nematode and viral diseases.

Practical: Introduction to the subject and allotment of small projects. Rearing techniques for different vectors. Toxicogenic insects and development of phytotoxamia. Important vectors, of virus, mycoplasma diseases. Transmission of stylet borne, circulative viruses, mycoplasma like diseases. Micro - metric studies on stylet path way of leaf hoppers. Influence of Pesticidal application on feeding behaviour. Demonstration of transmission of virus. Chemical control of insect vectors. Population assessment of vectors.

Suggested Reference

Veeresh, G. K., 1980, Teaching of insect pathology- in relation to biological control of pests and diseases.

Harris, H. F. and Maramarosh, K., 1980, *Vectors of Plant Pathogens.* Academic Press, London.

Basu, A. N., 1995, *Bemisia tabaci* (Gennadius)- *Crop pest and Principal Whitefly Vector of Plant Viruses.* Oxford and IBH, New Delhi.

Rajeev, K. Upadhyay, 2008, *Advances in Microbial control of Insect Pests.* Springer. P. 350.

HET 514 RESEARCH TECHNIQUES IN ENTOMOLOGY (0+1)

Study of insect collection devices, Collection of insects and mites, trapping, baiting, repelling *etc.* Rearing, preserving, fixing, staining, slide mounting, drawing and measuring of insects. Packing and shipping of insects, Population sampling and estimation of crop loss. Microtomy and photography, collection of literature, abstracting journals, scientific articles, reviewing, *etc.* Preparations of bibliography, scientific papers and proof reading.

Suggested Reference

Trigunayat, M. M., 2009, *A manual of Practical Entomology (field and laboratory guide).* Scientific Publishers (India). P. 359.

Chatterjee, P. B., 1997, *Plant Protection Techniques.* Bharati Bhawan, Patna. P. 323.

Saha, L. R., 2000, *Handbook of Plant Protection.* Kalyani Publishers, Cuttack. P. 928.

HET 515 PLANT QUARANTINE MEASURES (2+0)

Theory : Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine- domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status. Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration, APEDA, Import and Export of bio-control agents. Identification of pest/disease free areas; contamination of food with toxicants, microorganisms and their elimination. Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer

techniques of disinfestations/salvaging of infected material. WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

Suggested Reference

Rajeev, K. and Mukherjee, R. C., 1996, *Role of Plant Quarantine in IPM.* Aditya Books.

Rhower, G. G., 1991, Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture.* 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

HET 516 APPLICATION OF BIOTECHNOLOGY IN PEST MANAGEMENT (1+1)

Theory : Biotechnology- Definition - recombinant DNA technology and genetic control of insects. Cloning and isolation of insect genes - transportation of insect with clonal DNA- Prospects, novel genetic control strategies, meotic drive- Transportable elements. Transport of deleterious genes- Safety consideration - prospects of biotechnology in Entomopathogens- production of insect cell lines. Baculoviruses- Genetic improvement new virus strains - Basic principles and prospects of Genetic engineering in *Bacillus thuringsis*- Genetic improvement of parasitoids and predators of insect pests of crops. Biotechnology for beneficial and productive insects.

Practical : Production of entomopathogens in cell - lines- Baculoviruses selection of Baculoviruses with greater virulence. Increasing virulence of Baculoviruses by passage through alternate hosts- identification of mutants of Baculoviruses. Assignment on testing of components of biotechnology in IPM.

Suggested Reference

Marjorie, A. Hoy, 2003, *Insect Molecular Genetics – An Introduction to Principles and Applications.* Academic Press. P. 544.

HET 517 INSECT PATHOLOGY (1+1)

Theory : History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes. Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens. Examples of successful instances of exploitation of pathogens for pest management and mass production techniques of pathogens. Safety and

registration of microbial pesticides. Use of insect pathogens in integrated management of insect pests.

Practical : Familiarization with equipment used in insect pathology laboratory. Identification of different groups of insect pathogens and symptoms of infection. Isolation, culturing and testing pathogenicity of different groups of pathogens. Testing Koch's postulates. Estimation of pathogen load. Extraction of pathogens from live organisms and soil. Bioassays to determine median lethal doses.

Suggested Reference

Steinhaus, E. A., 1984, *Principles of Insect Pathology.* Academic Press, London.

Boucias, D. G. and Pendland, J. C., 1998, *Principles of Insect Pathology.* Kluwer Academic Publisher, Norwel.

Stock, S.P., Vandenberg, J., Glager, I and Beemare, N., 2009, Inset Pathogens: Molecular approaches and Techniques, CABI Pub.

HET 518 PLANT RESISTANCE TO INSECTS (1+ 1)

Theory : History and importance of resistance, principles, classification, components, types and mechanisms of resistance. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects. Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance- acquired and induced systemic resistance. Factors affecting plant resistance including biotypes for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world. Role of biotechnology in plant resistance to insects.

Practical : Screening techniques for measuring resistance; measurement of plant characters and working out their correlations with plant resistance; testing of resistance in important crops; bioassay of plant extracts of susceptible / resistant varieties; demonstration of antibiosis, tolerance and antixenosis.

Suggested Reference

Awasthi, V. B., 2001, *Principles of insect behaviour.* Scientific Publishers (India), Jodhpur. P. 237.

Dhaliwal, G. S. and Singh, R., 2005, *Host Plant Resistance to Insects- Concepts and Applications.* Panima Publ., New Delhi.

Painter, R. H., 1951, *Insect Resistance in Crop Plants.* MacMillan, London.

HET 519 SOIL ARTHROPODS AND THEIR MANAGEMENT (1+1)

Theory : Soil arthropods and their classification, habitats and their identification. Estimation of populations; sampling and extraction methods.

Role of arthropods in detritus feeding, litter breakdown and humus formation. Soil arthropod activity on soil properties. Harmful and beneficial soil arthropods and their management, interrelationship among arthropods and other soil invertebrates and soil microorganisms. Anthropogenic effects on soil arthropods.

Practical : Sampling, extraction methods and identification of various types of soil fauna; estimation and assessment of soil arthropod population; technique and culturing soil invertebrates.

Suggested Reference

Veeresh, G. K. and Rajagopal, D., 1988, Applied *Soil Biology and Ecology.* Oxford and IBH Publ., New Delhi.

Anderson, J. M. and ingram, J. S. I., 1993, *Tropical Soil Biology and Fertility: A Handbook of Methods.* CABI, London.

HET 520 VERMICULTURE AND VERMICOMPOSTING (1+1)

Theory : Vermiculture-definition and scope. Classification of earthworms up to families/ important genera. Earthworm distributuion. Earthworm activity on soil properties. Physio-chemical and biological properties. Reproductive patterns and earthworm biomass production. Earthworms and soil microorganisms. Vermicomposting. Definition and scope. Selection of earthworm species. Bioresources for vermicomposting. Structural designs and methodology. Factors influencing the process. Properties of vermicompost-compost enrichment. Vermi wash. Definition. Methodology for extraction, chemical composition and application. Vermimeal- definition and scope. Preparation and utility. Role of earthworms in sustainable agriculture. Earthworms as bio-concentrations and bio-indicators. Earthworms in human welfare.

Practical : Important key characters for earthworm identification. External and anatomical characters. Preparation of waste mix for vermicomposting. Comparative study on growth rate and population increase in different waste mix. Physico-chemical analyses of vermicompost. Microbial assay in vermicompost and earthworm gut. Vermiwash preparation. Effect of vermiwash and vermicompost on seed germination and plant growth. Laboratory observations on burrowing and feeding activity of earthworms. Visists to vermicomposting facilities in Karnataka.

Suggested Reference

NIIR Board, *The complete Technology book on vermiculture and vermicompost.* P. 354.

HET 521 VERTEBRATE PEST MANAGEMENT (1+1)

Theory : Vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals. Biology of beneficial birds. Population dynamic and assessment, patterns of pest damage and assessment, roosting and nesting systems in birds. Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods- Operational practices-baiting, biassays (LD50 studies), equipments and educative programmes.

Practical : Identification of important rodent and other vertebrate pests of agriculture, food preference and hoarding, social behavior, damage assessment, field survey, population estimation, control operation and preventive methods.

Suggested Reference

Barker, G.M., 2002, Molluscus as Crop Pests CABI. Pub.

Fitzwater, W. D. and Prakash, I., 1989, *Handbook of Vertebrate Pest Control.* ICAR, New Delhi.

Prakash, I. and Ghosh, R. P., 1987, *Management of Rodent Pests.* ICAR, New Delhi.

Ali, S., 1965, *The Book of Indian Birds.* The Bombay Natural History Society, Bombay.

HET 522 FOREST ENTOMOLOGY (1+1)

Theory : Insects in relation to forests interacting environmental or habitat factors. Role of insects in Nutrient cycling in forest ecosystems. 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. Bioecology, nature of damage, distribution and management strategies of important insect pests of timber and fruit yielding species of natural forests and plantations. Timber pests and their management. Non-insect pests of forest trees. Principles and concepts of forest pest management.

Practical : Study of insect damage and Sign categories.Identification of immature and adult stages of important insect pests of forest plants, plantation trees and timber. Visits to forest areas and forest plantations, timber Depos.

Suggested Reference

Jha, L. K. and Sen-Sarma, P. K., 1994, *Forest Entomology.* Ashish Publishing House, New Delhi, P. 387

HET 523 ECONOMIC ENTOMOLOGY (1+1)

Theory : Bee keeping- General colony management during different season. Seasonal management. Managing colonies for honey production and pollination. Artificial queen rearing. Pests and diseases of honeybees. Bee poisoning. Production and marketing of quality honey and value added honey products. Establishment and maintenance of apiaries. Study of different species of silkworms, characteristic features, moriculture, silk and its uses, pests and diseases of silkworms, rearing and management of silkworms. Lac insect-natural enemies and their management. Economic and public health importance of insect pests in human habitation and habitats, biology, damage and control of mosquitoes, houseflies, bed bugs, ants, termites, cockroaches, flies, silverfish, head and body lice, carpet beetles, cloth moths, crickets, wasps, house dust mites, insect pests of cattle, poultry, pet animals and their management. Principles and methods of pest management in residential places and public buildings, insecticides for domestic use and their safety, pre- and post construction termite proofing of buildings, appliances for domestic pest control. Rodent control methods. Organic methodsc of domestic pest management.

Practical:Assessing pest statusin dwellings(Labs,canteen or hostels),implementation of pest control against flies, mosquitoes, bed bugs, cockroaches and rodents. Pre- and post-construction termite proofing methods, control of silverfishes in the library. Visit to poultry units and assessing pest status in poultries. Evaluation of commercially available domestic insect pest control products through bioassays. Identification of honey bee species, bee castes and special adaptations, identification and handling of bee-keeping equipments. Handling of honey bees-hive and frame inspection. Honey extraction and processing methods of hive products extraction. Preparation of bee-keeping projects for funding. Visit to bee nursery and commercial apiaries. Silkworm rearing and management. Lac host and crop management technology and processing of lac. Products and bye products of lac.

Suggested Reference

Aruga, H., 1994, *Principles of Sericulture.* Oxford and IBH, New Delhi.

Atwal, A. S., 2006, *The world of the Honey Bee.* Kalyani Publ., New Delhi.

Singh, S., 1975, *Beekeeping in India.* ICAR, New Delhi.

HET 524 PESTS OF HORTICULTURAL CROPS (2+1)

Theory

Important pests, nature of damage, damaging symptoms, Bio ecology and management of major pests of Fruit Crops (Mango, Banana, Guava, Citrus Sapota, Grapes, Pomegranate, Papaya, Pineapple, Ber and Apple).

Important pests, nature of damage, damaging symptoms, Bio ecology and management of major pests of Vegetable Crops (Brinjal, Tomato, Chilli, Bhendi, Cruciferous vetables, Cucurbiaceous vegetables, potato, Sweet potato Leguminous & Leafy begetables).

Important pests, nature of damage, damaging symptoms, Bio ecology and management of major pests of Plantation Crops (Coconut, Arecanut, Cashew, Coffee, Tea, Cocoa)

Important pests, nature of damage, damaging symptoms, Bio ecology and management of major pests of Spices and Condiments Crops (Turmeric, Ginger, Cardamom, Black pepper and betel vine)

Important pests, nature of damage, damaging symptoms, Bio ecology and management of major pests of flower Crops (Rose, Carnation, Gerbear Jasmine, Chrysanthamum, Marigold)

Important pests, nature of damage, damaging symptoms, Bio ecology and management of major pests of Medicinal and Aromatic Crops (Ashwagandha, Solanum, Coleus, tuberose, Geranum, Tulsi).

Important pests, nature of damage, damaging symptoms, Bio ecology and management of major storage pests of Horticultural crops.

Important pests, nature of damage, damaging symptoms, Bio ecology and management of major Non- Insect pests of Horticultural crops.

Particles: Collection of 50 insect pests of above mentioned crops. Study of symptoms and nature of damage of the pests of above crops. Rearing of five crop pests and preserving their developmental stages. Visit to research stations/ farmers fields.

Suggested Reference

Panwar, V.P.S., 2002, *Agricultural insect pests of crops and their control.* Kalyanipublishers, Cuttack. 0.286.

Kumaresan, D., Regupathy, A. and Baskran, P., 1988 *Pests of Spices.* Rajalakshimi publications, Nagercoil.

Parvath Redy. P. Abraham verghse and Krishnakumar, N.K., 2001. *Integrated pest Management in Horticultural Ecosystems.* Capital Publishing Copmany New Delhi P 292.

Prasad.T.V., Third Edn, Hand book of Entomology, New vishals pub

Prasad D., 2008, Insect Pest and Disease management, Day a pub.

HET525 APPLIED APICULTURE 1+1

Theory :

Scope and importance of bee keeping. History of bee keeping, Honey bee speices and caste differentiation. Marpholgy and Anotomy of Honey bees. biology of bee, communication behaviour in honey bees. Bee keeping Appliances. Establishment and management of apiary : management during different seasons. Artificial feeding, colony division and colony uniting, hiving of natural colonies. Bee flora, bee hive products and their importance: Honey extraction, processing and its quality parameters. Other hive poducts *viz.*, bee wax, propolis, Royal jelly, Pollen and bee venom, Artifical queen rearing, Honey bees as pollinators. Migeratory bee keeping, Pests and diseases of honey bees and thir management, Bee poisoning and preventive measures, econimics of bee keeping and apiculture as an entrepreneurship

Practicals :

- Identification of Honey bee species.
- Honey bee castes.
- Biology of honey bees.
- Marphology of honey bees.
- Anotomy of honey bees.
- Bee keeping equipments.
- Hiving of natural colonies.
- Handling of honey bee hives, Frame inespection and assessing colony performance.
- Bee flora.
- Division and uniting of colonies and artificial feeding.
- Honey, Wax extraction and processing methods.
- Study of bee pests and diseases.
- Preperation of bankable bee keepign project.
- Visit to honey bee nursery and commercial apiaries.

References: Phillips,E.F., 2003, Beekeeping, Agrobios (India)

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

A. Core courses

Course No.	Title of the course	Credit Hours
SAC 501	ANALYTICAL TECHNIQUES IN SOIL AND PLANT ANALYSIS	1+1
SAC 502	SOIL MINERALOGY, GENESIS, SURVEY AND CLASSIFICATION	2+1
SAC 503	SOIL PHYSICS	2+1
SAC 504	SOIL CHEMISTRY	2+1
SAC 505	SOIL BIOLOGY AND SOIL BIOCHEMISTRY	1+1
SAC 506	SOIL FERTILITY AND NUTRIENT MANAGEMENT	2+1
	Total	**16**

B. Optional Courses

Course No.	Title of the course	Credit Hours
SAC 507	MANAGEMENT OF PROBLEMATIC SOILS AND WATERS	1+1
SAC 508	SOIL, WATER AND AIR POLLUTION	1+1
SAC 509	SOIL TESTING & FERTILISER RECOMMENDATION	1+1
SAC 510	MANURES & FERTILISERS	1+1
SAC 511	AGRICULTURAL CHEMICALS	1+1
SAC 512	SOIL EROSION AND CONSERVATION	1+1

A.CORE COURSES

SAC 501 ANALYTICAL TECHNIQUES IN SOIL AND PLANT ANALYSIS 1+1

Theory : Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation-reduction and complexo-metric titration; electrochemical titration of clays. Nutrient potentials and potential buffering capacities and fixation capacity of soils for phosphorus, ammonium and potassium; estimation of phosphorus, ammonium and potassium. Principles of visible, ultraviolet and infrared spectrophotometery, atomic absorption spectroscopy, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry. Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods.

Practical : Principles of analytical chemistry, Sampling of soils, water, effluents and plant, Estimation of electrochemical properties of soils, Estimation of cation and anion exchange capacity of soils, Chemical analyses of soils and interpretation and recommendation, Chemical analyses of plant and interpretation and recommendation.

Suggested Reference

Saha, A.K., *Methods of physcial and chemical analysis of soil*
Chopra, S.L., and Kanwar, J.S., *Analytical Agricultural Chemistry*
A.K. Gupta., *Practical Manual for Agricultural Chemistry*
ISSS, New Delhi., *Fundamentals of Soil Science*
Chatwal and Anand., I*nstrumental Methods of Chemical Analysis*
Dhyan Singh et al., *Manual on soil, plant and water analysisNyle* C.Brady and Ray R. Weil., *Nature and properties of soils*

SAC 502 SOIL MINERALOGY, GENESIS, SURVEY AND CLASSIFICATION 2+1

Theory : Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism. Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils. Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils. Concept of soil individual; soil classification systems – modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness. Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps. Landform – soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and

application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Practical : Identification and quantification of minerals in soil fractions by X-ray and different methods. Morphological properties of soil profile in different landforms, Classification of soils using soil taxonomy, Calculation of weathering indices and its application in soil formation, Grouping soils using available data base in terms of soil quality, Aerial photo and satellite data interpretation for soil and land use, Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and construction of maps in different scales, Land use planning exercises using conventional and RS tools

Suggested Reference

Sehgal, J., *A Text Book of Pedology*

Saha, A.K., *Methods of physcial and chemical analysis of soil*

ISSS, New Delhi., *Fundamentals of Soil Science*

PC Das., *Soils in India*

Dipak Sarkar and Abhijit Haldar., *Fundamental Principles of Soil Science*

Nyle C. Brady and Ray R. Weil., *Nature and propertices of Soils*

SAC 503 SOIL PHYSICS 2+1

Theory : Scope of soil physics and its relation with other branches of soil science; soil as a three phase system. Soil texture, textural classes, mechanical analysis, specific surface. Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation. Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential. Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils. Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum. Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management. Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical : Mechanical analysis by pipette and international methods, Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum blocks. Determination

of soil-moisture characteristics curve and computation of pore-size distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields

Suggested Reference

BP Gildiyal and RP Tripati., *Soil Physics*
Baver, L.D., *Soil Physics*
Rattan Lal and MK Shukla., *Priciples of Soil Physics*
ISSS, New Delhi., *Fundamentals of Soil Science*
Nyle C. Brady., and Ray R Weil., *Nature and properties of soils*
Agronomy No.9; ASA, USA., *Methods of soil analysis Part I- Physcial and Mineralogical properties*

SAC 504 SOIL CHEMISTRY 2+1

Theory: Chemical (elemental) composition of the earth's crust and soils. Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics. Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/ flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions. Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange – innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition. Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects. Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity. Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments. Chemistry and electrochemistry of submerged soils.

Practical : Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of s oil humic and fulvic acids by visible spectrophotometric

studies and the Ä (E4/E6) values at two pH values, Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by BaCl2-TEA method, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

Suggested Reference

Kim H Tan., *Principles of Soil Chemistry*

Kumuda, K., *Chemistry of Soil Organic Matter*

Marshall CE., *The Physical Chemistry and Mineralogy of Soils*

ISSS, New Delhi., *Fundamentals of Soil Science*

Page et al (Ed) SSSA book Series, UAS., *Methods of Soil Analysis - Part 2: Chemical and microbiological propertices*

Page et al SSSA Book Series, UAS.,*Methods of Soil Analysis - Part 3: Chemical Methods*

Jackson, ML., *Soil Chemical Analysis*

Bear, F., *Chemistry of the Soil*

Barrow, G.M., *Physical Chemistry*

Kyuma K., *Paddy soil science*

Nyle C. Brady and Ray R Weil., *Nature and propertices of soils*

SAC 505 SOIL BIOLOGY AND SOIL BIOCHEMISTRY 1+1

Theory : Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota. Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora. Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil. Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost. Biofertilizers – definition, classification, specifications, method of production and role in crop production.

Practical : Determination of soil microbial population, Soil microbial biomass, Elemental composition, fractionation of organic matter and functional groups, Decomposition of organic matter in soil, Soil enzymes, Measurement of important soil microbial processes such as ammonification, nitrification, N2 fixation, S oxidation, P solubilization and mineralization of other micro nutrients Study of rhizosphere effect

Suggested Reference

Buscot, F and Ajit Verma., Micro organisms in soils: Roles in Genesis and Formation

ISSS, New Delhi., *Fundamentals of Soil Science*

Page et al (Ed) SSSA Book Series, UAS., *Methods of Soil Analysis - Part 2: Chemical and microbiological propertices*

Sadashivam, S and Manickam, A ., *Biochemical methods*

Bollag, J.M., and Stotzky., Soil Biochemistry

Nyle C. Brady and Ray R Weil., *Nature and propertices of soils*

SAC 506 SOIL FERTILITY AND NUTRIENT MANAGEMENT 2+1

Theory : Soil fertility and soil productivity; nutrient sources – fertilizers and manures; essential plant nutrients - functions and deficiency symptoms. Soil and fertilizer, nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation - types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency. Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions. Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions. Sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers. Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability. Common soil test methods for fertilizer recommendations; quantity– intensity relationships; soil test crop response correlations and response functions. Fertilizer use efficiency; blanket fertilizer recommendations – usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated

nutrient management. Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical : Principles of colorimetry, Flame-photometry and atomic absorption spectroscopy, Chemical analysis of soil for total and available nutrients, Analysis of plants for essential elements

Suggested Reference

J.S. Kanwar et al., *Soil Fertility Theory and Practice*
Womwe, P.L and Swift, M.j., *Soil Management of Tropical Soil* Fertiility
Mengel K and Kirkby, EA., *Principles of Plant Nutrition*
ISSS, New Delhi., *Fundamentals of Soil Science*
Jackson, M.L., *Soil Chemical Analysis*
Dipak Sarkar and Abhijit Haldar., *Fundamental Principles of Soil Science*
Henry DF Boyd GE 2nd ed ., Soil fertility
Nyle C. Brady and Ray R Weil., *Nature and propertices of soils*

SAC 507 MANAGEMENT OF PROBLEMATIC SOILS AND WATERS 1+1

Theory : Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible**.** Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties. Management of salt-affected soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils. Acid soils - nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management. Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality. Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

Practical : Characterization of acid, acid sulfate, salt-affected and calcareous soils, Determination of cations (Na^+, K^+, Ca^{2+} and Mg^{2+}) in ground water and soil samples, Determination of anions (Cl^-, SO_4^{2-}, CO_3^{2-}, and HCO_3^-) in ground waters and soil samples, Lime and gypsum requirements of acid and sodic soils

Suggested Reference

R Lal., *Soil Quality and Soil Erosion*
Handbook No.60, USDA., *Saline and Alkali Soils*
Nyle C. Brady and Ray R Weil., *Nature and propertices of soils*
Chabbra R., *Soil Salinity and Water Quality*
Henry DF Boyd GE 2nd ed ., *Soil fertility*

SAC 508 SOIL, WATER AND AIR POLLUTION 1+1

Theory : Soil, water and air pollution problems associated with agriculture, nature and extent. Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills *etc.;* air, water and soil pollutants - their CPC standards and effect on plants, animals and human beings. Sewage and industrial effluents – their composition and effect on soil properties/ health, and plant growth and human beings; soil as sink for waste disposal. Pesticides – their classification, behavior in soil and effect on soil microorganisms. Toxic elements – their sources, behavior in soils, effect on nutrients availability, effect on plant and human health. Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases – carbon dioxide, methane and nitrous oxide. Remediation/ amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical : Sampling of sewage waters, sewage sludge, solid/liquid industrial wastes, polluted soils and plants, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Air sampling and determination of particulate matter and oxides of sulphur, Visit to various industrial sites to study the impact of pollutants on soil and plants

Suggested Reference

Dhyan Singh et al., *Manual on Soil, plant and water analysis*
Ibrahim A Mirsal., *Soil Polluation: Origin, Monitoring and Remediation*
James V Livingston., *Agriculture and Soil Poullution*
KK Singh et al., *Air, Water and Soil pollution*
Yaron et al., *Soil pollution processes and dynamics*
Minkina et al *Heavy metal compounds in soil*
Pradyot Patnaik., *Handbook of environmental Analysis*

SAC509 SOIL TESTING & FERTILISER RECOMMENDATION 1+1

Theory : Principles of soil testing; Factors affecting the availability of nutrients; Field sampling for soil testing. Testing soils for pH, plant nutrients, Lime and gypsum requirement; Interpretation of soil test results for fertilizer recommendation. Experimental methods for correlation and calibrating soil tests; The changing philosophy of soil test interpretation, Principles and practices in plant analysis; Leaf analysis as an aid in fertilizer recommendation; Operation and management of commercial soil testing and plant analysis laboratories; Concepts of soil testing and response studies in soil fertility evaluation; Visual and hidden hunger symptoms in plants and their diagnostic techniques; Crop logging techniques, biological methods in determining nutrients in soils; Mitscherlich pot culture methods for Neubauer techniques.

Practical: Collection soil samples from varying fertility levels, analysis, fertility ratings and computations of nutrient indices, Preparation of soil fertility maps, Fertilizer recommendation to crops based on soil test data: Use of soil test crop response concept in computing target yield of crops; Determination of available nutrients using pot culture method and Neubauer techniques.

Suggested Reference

B.S. Stewart., *Advance in siol science*

Grewing J.R., *Fertilizer recommendation Guide*

R.Lal and Stewart, B.A., *Soil specific farming*

Fageria, N.K., *The use of nutrients in crop plants*

SAC 510 MANURES & FERTILISERS 1+1

Theory : Fertilizers – production, consumption and future projections with regard to nutrient use in the country and respective states. Manures-classification, chemistry, nutrient contents of bulky and concentrated organic manure. Manufacturing processes for different fertilizers (nitrogenous, phosphatic and potassic fertilizers) using various raw materials, characteristics and nutrient contents. Recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order. New and emerging issues in fertilizer technology – production and use of slow and controlled release fertilizers, supergranules fertilizers and fertilizers for specific crops/situations. Environmental pollution due to fertilizer use. Biofertilizers – important biofertlisers like Rhizobium, Azotobacter, Azospirilum, Micorrhiza Production efficiency and capacity utilization; quality control and legal aspects- fertilizer control order.

Practical : Determination of moisture content in fertilizers, Qualitative tests of inorganic fertilizers, Determination of total nitrogen in fertilizers, Determination of water soluble P_2O_5 in fertilizer, Determination of water soluble K_2O in K fertilizers, Analysis of manures for different nutrients, Determination of lime and gypsum contents in amendments, Visit to fertilizer quality control laboratories.

Suggested Reference

Basak R.K., *A text book of fertilizers*

Gaur, AC et al., *Organic manures*

IDFC., *Fertilizer* manual

Shishir Sinha et al., *Fertilizer Technology*

Sunilkumar and Ajay Bharath., *Management of organic wastes*

Polprasert C., *Organic wastes recycling*

Gustafson, A.F.,*Hand of fertilizers*

SAC 511 AGRICULTURAL CHEMICALS 1+1

Theory : Definition, IUPAC approved terminology, statistics of production and consumption. Plant protection chemicals: Pesticides – classification of pesticides by different methods. Botanical insecticides, structure,

properties, mode of action and uses of conventional insecticides such as nicotine, pyrethrins and rotenones. Structure, properties, mode of action and uses of Insecticides- chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids. Fungicides - inorganic, organic-heterocyclic, formamide, alkane, alkane carboxylic acid and miscellaneous groups. Herbicides- classification and important groups- phenoxy compounds, substituted ureas, amides, thiocarbamates, triazines, pyridines, imidazolines and sulphonyl ureas. Nematicides - aliphatic halogen compounds, methyl isocyanate liberators, organophosphates and carbamates. Formulation of pesticides - definition, classification. Pesticide adjuvants: synergists**.** Pesticide residue: Concept definition, significance and analysis as per BIS specifications; Insecticide Act, Directorate of Plant Protection, Quarantine and Storage.

Practical : pH, Acidity/ Alkalinity, Bulk density, Wettability, Specific gravity, Suspensibility of pesticides, Titrimetric procedure for active ingredient analysis of Pesticide formulation, Extraction procedures for pesticide residues from soil and plant samples, Cleanup procedures for pesticide residues from soil and plant samples, Ultra- Violet (UV) Spectrophotometric methods in Pesticide, Infrared (IR) Spectroscopy, Thin Layer Chromatograph (TLC), Gas Chromatograph (GC) in Pesticide formulation/ residue analysis, High Performance Liquid Chromatograph (HPLC) in Pesticide formulation/ residue analysis, Studies on Bioassay techniques for Persistence of herbicides, Calculations, Reporting and Interpretation of the Pesticide Residue Data, Safety measures in handling pesticides, BIS standards for commonly used pesticides

Suggested Reference

Cheng HH (Ed)., *Pesticides in the Soil Environment: Processes, Impacts and Modelling*

Guenzi, W.D(Ed)., *Pesticides in Soil and Water*

Panda, H., *Pesticides, Insecticides, fungicides and herbicides with formula and processes*

GWA Milne., *Pesticides an introduction to 1800 pest controlling chemicals*

Roy MK., Chemistry of *Pesticides*

SAC 512 SOIL EROSION AND CONSERVATION 1+1

Theory: History, distribution, identification and description of soil erosion problems in India. Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity - estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation. Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country. Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout. Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands. Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds.

Practical : Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index, Computation of kinetic

Suggested Reference

Hudson Norman (3rd ed)., *Soil Conservation*

Wallingford *Soil resilience and sustainable land use*

Wischmeier., *A guid to conservation planning*

SUPPORTING COURSES FOR M.Sc DEGREE PROGRAMME
AGRICULTURAL ECONOMICS

COURSE LIST

AEC 513 INTELLECTUAL PROPERTY MANAGEMENT 1+0
AEC 514/AMC 513 COMMODITY FUTURES TRADING 2+0

COURSE CONTENT

AEC 513 INTELLECTUAL PROPERTY MANAGEMENT 1+0

Theory : World Trade Organization- Agreement on Agriculture (AoA) and Intellectual property rights (IPR) – Importance of Intellectual property management-IPR and Economic growth-IPR and biodiversity- Major areas of concern in intellectual property management- Technology transfer and commercialization- Forms of different intellectual properties generated by agricultural research. Discovery versus invention- patentability of biological inventions- method of agriculture and horticulture- procedure for patent protection: preparatory work, Record keeping. Writing a patent document, filing the patent document-types of patent applications-patent application under the Patent cooperation treaty (PCT). Plant genetic resources-importance and conservation- Sui Generic system- Plant Varieties Protection and Farmers Rights Act- registration of extinct varieties- Registration and protection of New Varieties/Hybrids/Essentiality derived varieties –Dispute prevention and settlement of Farmers' Rights. Trademark- Geographical indications of goods and commodities –copy rights-designs- biodiversity protection- Economic implications of Sanitary and Phytosanitary measures. Procedures for commercialization of technology –Valuation, costs and pricing of technologies-Licensing and implementation of Intellectual Properties-Procedures for commercialization –Exclusive and non exclusive marketing rights- Research exception and benefit sharing.

AEC 514/AMC 513 COMMODITY FUTURES TRADING 2+0

Theory : History and Evolution of commodity markets – Terms and concepts: spot, forward and futures Markets – factors influencing spot and future markets. Transaction and settlement – delivery mechanism - role of different agents - trading strategies - potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets. Risk in commodity trading, importance and need for risk management measures - managing market price risk: hedging, Options, speculation, arbitrage, swaps - pricing and their features. Speculatory mechanism in commodity futures. Important global and Indian commodity exchanges - contracts traded – special features -Regulation of Indian commodity exchanges - FMC and its role. Criticism of the future markets in agriculture in a country like INDIA. Fundamental Vs Technical analysis – construction and interpretation of charts and chart patterns for analyzing the market trend – Market indicators - back testing. Introduction to technical analysis software – analyzing trading pattern of different commodity groups.

AGRICULTURAL ENGINEERING

PROCESSING AND FOOD ENGINEERING

COURSE LIST

PFE 506	FOOD PROCESSING EQUIPMENT AND PLANT DESIGN	1+1
PFE 507	FRUITS AND VEGETABLES PROCESS ENGINEERING	1+1

COURSE CONTENT

PFE 506 FOOD PROCESSING EQUIPMENT AND PLANT DESIGN 1+1

Theory : Design considerations of processing agricultural and food products. Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation, membrane separation. Human factors in design, selection of materials of construction and standard component, design standards and testing standards. 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 36 economic plant size; Product and process design, process selection, process flow charts, computer aided development of flow charts. Hygenic design aspects and worker's safety, functional design of plant building and selection of building materials, estimation of capital investment, analysis of plant costs and profitabilities, management techniques in plant design including applications of network analysis, preparation of project report and its appraisal.

Practical : Detailed design and drawing of mechanical dryers, milling equipment, separators, evaporators, mixers and separators. Each individual 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 selection, estimation of plant size, process and equipment selection, process flow-sheeting, plant layout, and its evaluation and profitability analysis.

PFE 507 FRUITS AND VEGETABLES PROCESS ENGINEERING 1+1

Theory : Importance of post harvest technology of fruits and vegetables, structure, cellular components, composition and nutritive value of fruits and vegetables, fruit ripening, spoilage of fruits and vegetables. Harvesting and washing, pre-cooling, preservation of fruits and vegetables, blanching, commercial canning of fruits and vegetables, minimal processing of fruits and vegetables. Cold storage of fruits and vegetables, controlled atmosphere packaging of fruits and vegetables, gas composition, quality of storage. Dehydration of fruits and vegetables, methods, osmotic dehydration, foam mat drying, freeze drying, microwave heating, applications, radiation preservation of fruits and vegetables, irradiation sources. Intermediate moisture foods, ohmic heating principle, high pressure processing of fruits and vegetables, applications, sensory evaluation of fruit and vegetable products, packaging technology for fruits and vegetables, general principles of quality standards and control, FPO, quality attributes.

Practical : Determination of size, shape, density, area-volume-mass relationship of fruits and vegetables, sugar-acid ratio of fruits, evaluation of washer, grader and packaging methods, experiments on drying of fruits and vegetables, controlled atmosphere storage and quality evaluation.

SOIL AND WATER ENGINEERING

COURSE LIST

SWE 502	DESIGN OF FARM IRRIGATION SYSTEMS	2+1
SWE 505	SOIL AND WATER CONSERVATION ENGINEERING	1+1
SWE 507	WATERSHED MANAGEMENT AND MODELLING	1+1
SWE 512	CONTROL OF POLLUTION FROM SOLID WASTES	2+0

COURSE CONTENT

SWE 502 DESIGN OF FARM IRRIGATION SYSTEMS 2+1

Theory : Concepts of Irrigation; Irrigation principles, losses, conveyance, distribution; Application, scheduling parameters, water budgeting. Surface irrigation, hydraulics of water advance and recession, hydraulic resistance to flow, gravity irrigation. Design of Border irrigation, furrow irrigation, check basin irrigation; Sub Irrigation methods and concepts. Preliminary design criteria of sprinkler and micro irrigation systems, hydraulics of sprinkler and micro irrigation systems. Design of lateral, submain and main line of sprinkler and

micro irrigation. Fertigation aspects. Underground water conveyance system; Evaluation of irrigation systems and practices.

Practical : Design and evaluation of border, furrow, check basin, sprinkler and micro irrigation, computation of frictional losses, Design of underground water conveyance systems, economics of irrigation methods, visit to irrigated farms.

SWE 505 SOIL AND WATER CONSERVATION ENGINEERING 1+1

Theory : Probability and continuous frequency distribution; Fitting empirical distributions. Layout and planning of soil and water conservation measures; Design principles of soil and water structures including contour bunds and terraces; Gully control measures. Hydraulic jump and energy dissipaters for soil conservation structures; Hydrologic, hydraulic and structural design of drop structures. Sediment deposition process. Estimation of sediment load, earthen dams, seepage through dams and stability analysis. Rainwater harvesting, Flood control and stream bank protection measures.

Practical : Design of Drop spillway, chute spillway, drop inlet spillway, hydraulic jump calculation, design of bench terrace, contour bunds and contour trenches, design and problems on earthen dam, silt detention tanks and check dams, visit to soil conservation structures sites.

SWE 507 WATERSHED MANAGEMENT AND MODELLING 1+1

Theory : Problems of desertification and degradation. Models of sediment yield. Survey, monitoring, reclamation and conservation of agricultural and forest lands, hill slopes and ravines. Concept of operational watershed. National land use policy, legal and social aspects. Watershed management research instrumentation and measurement, problem identification, simulation and synthesis. Modelling of flood and drought phenomenon, drought management and dry farming

Practical : Preparation of watershed development proposal, preparation of watershed evaluation report. Application of Models of flood and drought phenomenon. Application of watershed models.

SWE 512 CONTROL OF POLLUTION FROM SOLID WASTES 2+0

Theory : Definition. Sources. Quality, Classification and characteristics of solid waste collection, Transport and reduction at source. Handling, Collection , Storage, transport of Solid wastes. Disposal methods and their merits and demerits. Processing of solid wastes. Fertilizers, fuel and food values. Recycling and reuse materials and energy recovery operations.

AGRICULTURAL EXTENSION

COURSE LIST

AEX 502	DEVELOPMENT COMMUNICATION AND INFORMATION MANAGEMENT	1+1
AEX 503	DIFFUSION AND ADOPTION OF INNOVATIONS	1+1

COURSE CONTENT

AEX 502 DEVELOPMENT COMMUNICATION AND INFORMATION MANAGEMENT 1+1

Theory : Communication process – concept, elements and their characteristics – Models and theories of communication – Communication skills– fidelity of communication, communication competence and empathy, communication effectiveness and credibility, feedback in communication, social networks and Development communication – Barriers in communication, Message – Meaning, dimensions of a message, characteristics of a good message, Message treatment and effectiveness, distortion of message. Methods of communication – Meaning and functions, classification. Forms of communication – Oral and written communication, Non-verbal communication, interpersonal communication, organizational communication. Key communicators – Meaning, characteristics and their role in development. Media in communication – Role of mass media in dissemination of farm technology, Effect of media mix for Rural People. Modern communication media – Electronic video, Tele Text, Tele conference, Computer Assisted Instruction, Computer technology and its implications. Agricultural Journalism as a means of mass communication, Its form and role in rural development, Basics of writing – News stories, feature articles, magazine articles, farm bulletins and folders. Techniques of collection of materials for news stories and feature articles; Rewriting Art of clear writing, Readability and comprehension testing procedures; photo journalism, communicating with pictures, Radio and TV Journalism, Techniques of writing scripts for Radio and TV

Practical : Exercises on Communication credibility, empathy, competence and communication skills. Visit to Press, Radio, AIR, Doordarshan, Press Trust of India, Tele Conference centre. Writing future articles, script writing for Radio, Script writing for TV, Measuring readability by using different formulae. Visiting progressive farmers to develop success stories.

AEX 503 DIFFUSION AND ADOPTION OF INNOVATIONS 1+1

Theory : Diffusion – concept and meaning, elements; traditions of research on diffusion; the generation of innovations; innovation-development process; tracing the innovation-development process, converting research into practice. The adoption process- concept and stages, dynamic nature of stages, covert and overt processes at stages, the innovation-decision process – a critical appraisal of the new formulation. Adopter categories – Innovativeness and adopter categories, adopter categories as ideal types, characteristics of adopter categories; Perceived attributes of Innovation and their rate of adoption, factors influencing rate of adoption. Diffusion effect and concept of over adoption, opinion leadership measurement and characteristics of opinion leaders, monomorphic and polymorphic opinion leadership, multi-step flow of innovation; concepts of homophily and heterophily and their influence on flow of innovations; Types of innovation-decisions – Optional, Collective and Authority and contingent innovation decisions; Consequences of Innovation-Decisions – Desirable or Undesirable, direct or indirect, anticipated or unanticipated consequences; Decision making – meaning, theories, process, steps, factors influencing decision making.

Practical : Case studies in individual and community adoption process, content analysis of adoption studies, Identification of adopter categories on a selected technology, study of attributes of current farm technologies, Identification of opinion leaders, Sources of information at different stages of adoption on a selected technology, study of factors increasing or retarding the rate of adoption, presentation of reports on adoption and diffusion of innovations.

AGRICULTURAL MARKETING AND COOPERATION

COURSE LIST

AMC 509	INTERNATIONAL BUSINESS	2+0
AMC 510	AGRICULTURAL AND FOOD MARKETING	2+1
AMC 511	GRADING AND QUALITY CONTROL IN AGRICULTURAL AND FOOD INDUSTRY	1+1

COURSE CONTENT

AMC 509 INTERNATIONAL BUSINESS 2+0

Theory : Introduction-Evolution-Nature of International Business- Why go International- Stages of Internationalization- International Business.Approaches-Theories of International Business -Competative advantage of Global business-Problems of international business-competative advantage

in a Global setting. International Business Environment-Introduction- Social and Cultural Environment- Technological Environment- Economic Environment- Political Environment.Modes of Entering International Business-International Business Analysis- Modes of Entry: Exporting, licensing, franchising, contract manufacturing, management contracts, turnkey projects, foreign direct investment, alliances like mergers and acquisitions, joint ventures- Comparison of Different Modes of Entry- Functional Alliances- Managing Conflict Situations- Break up of Alliances. Globalization-Introduction- Meaning and Definition- Features- Stages of Globalization-Globalization of Markets, Production, Investment and Technology-Globalization : Is it Desirable?- Advantages and Disadvantages- Methods of Globalization- Essential Conditions for Globalization – Globalization and India. Multinational Corporations-Definition- Distinction among IC, MNC, GC and TNC- Factors Contributed for the Growth of MNCs- Advantages and Disadvantages of MNCs- Control over MNCs- Organization Design and Structure of MNCs, Relationship between Headquarters and Subsidiaries-MNCs in India- The Indianisation of Transnational. Foreign Direct Investment-Introduction- Foreign Direct Investment in the world economy- Trends in FDI-The direction of FDI-The source of FDI- The form of FDI: Acquisitions versus Green Field Investments- Horizontal Foreign Direct Investment- Vertical Foreign Direct Investment- Focus on Managerial Implications.

AMC 510 AGRICULTURAL AND FOOD MARKETING 2+1

Theory : Definition and concept, role of marketing in economic development, classification of markets. Approaches to study marketing system-functional-institutional-commodity and structural approaches. Marketing channels and price spread. Marketing Efficiency-Technical and Economic Efficiency. Evaluation of marketing efficiency-structure-conduct and performance, marketing margin and price spread, market integration method. Analysis of marketing systems for a) food grains b) commercial crops c) horticultural crops d) livestock and animal products, and f) agricultural inputs.

Food consumption and marketing – Food preferences, consumption and expenditure patterns, demographics of food consumption – Food processing and manufacturing – Innovations and branding in food manufacturing, the structure of food manufacturing industry, location of food processing and problems of food processors. Food wholesaling and retailing – Food wholesaling, food retailing, competition and pricing in food retailing, the food service market. Government and institutional role in agricultural and food

marketing – Market Legislation and Regulation, Commodity Boards and Corporations, Marketing Co-operatives.

Practical : Identification of Marketing Channels and Analysis of Price Spread. Evaluation of Marketing Efficiency – Temporal Efficiency, Spatial Efficiency and Structure – Conduct – Performance Analysis. Market integration studies – Performance evaluation of Marketing Boards, Co-operatives and other Marketing parastatals.

AMC 511 GRADING AND QUALITY CONTROL IN AGRICULTURAL AND FOOD INDUSTRY 1+1

Theory : Standardization and Grading – Its meaning scope and importance. Institutions related to standardization and grading. ISO (International organization for standardization). Bureau of Indian standards, Directorate of Marketing and Inspection, Objectives and functions and their role in standardization. Grading of food grains, pulses, commercial crops, oil seeds, spices, horticultural produce, fruits and vegetables. Grading of livestock, poultry, fisheries. Food adulteration and food poisoning and detection, food hygiene. Sanitary and phytosanitory measures. Quality management, quality parameters, quality specifications. Total quality management.

Practical : Introduction to grading laboratory, study of sampling and grading instruments, principles of sampling, estimation of moisture in food grains by Hot air Oven method, infrared moisture balance method. Estimation of different refractions in important cereals. Physical analysis of pulses and oil seeds. Detection of some common adulterants in foods by simple and quickest methods. Visit to DMI, Regional Agmark laboratory, Bureau of Indian Standards for food safety industry and analytical quality control.

AGRICULTURAL MICROBIOLOGY

COURSE LIST

AMB 505	MICROBIOLOGICAL TECHNIQUES	0+2
AMB 511	INDUSTRIAL MICROBIOLOGY	1+1
AMB 512	BIOFERTILIZER TECHNOLOGY	1+1
AMB 513	BIOLOGY AND PRODUCTION OF MYCORRHIZAE	2+1
AMB 515	FOOD MICROBIOLOGY	2+1
AMB 510	SOIL MICROBIOLOGY	2+1

COURSE CONTENT

AMB 505 MICROBIOLOGICAL TECHNIQUES 0+2

Practical: Use of Microscope; including phase contrast; Dark field, UV and Fluorescent microscopy- Photomicrography- Microscopic measurements of cells and study of microorganisms under microscopes. Staining techniques to examine the morphology of microorganisms; negative staining, Grams stain, acid fast stain, flagella stain, capsule stain etc. Formulation and preparation of media for culturing microorganisms, nutrient broth and agar media. Differential and selective media for bacteria, fungi, algae etc. Enrichment culture technique for specialized groups of bacteria. Methods of isolation of microorganisms; pour plate, dilution plate, tissue culture, anaerobic culture *etc.* Pure culture techniques and maintenance of stock cultures of various groups of microorganisms. - Principles and practices of manometry; Identification of microorganisms and examination of Koch's postulates in case of pathogens; Measurement of microbial activities-dehydrogenase activity, acid and alkaline phosphatase activity; urease activity; Measurement of microbial biomass through estimation of microbial-C.

AMB 510 SOIL MICROBIOLOGY 2+1

History of soil microbiology. Distribution-microbial population of different soils of the world. Study of the microorganisms in soils: quantitative and qualitative estimations of the population. Soil microorganisms in relation to fertility level. Influence of various soil factors on soil microorganisms moisture, pH, temperature, organic matter, agronomic practices, etc; distribution of microorganisms in organic manures and composts; microorganisms in soil processes; carbon cycle; organic matter decomposition, humus formation; nitrogen cycle; nitrogen fixation, symbiotic, non symbiotic, associative organisms; ammonifictions nitrification denitrification reactions; organisms involved; factors affecting nitrogen transformation; microbial transformation of phosphorus, iron sulphur, micronutrients in soil; phosphours solubilisation by phosphobacteria and P mobilization by mycorrhizal fungi; interrelationships between plants and microorganisms, rhizosphere concept and the study of rhizosphere microorganisms-interrelationships of microorganisms with plant roots and soil quantitative and qualitative studies of rhizosphere micorflora-R:S ratio and its significance. Spermosphere and Phyllosphere microorganisms and their importance in plant growth; pesticides and other agrochemical recalcitrant molecules; plant growth regulators and phytotoxin production by microorganisms; use of microorganisms for pest and disease control; effect of

pesticides on soil microflora; ecology of microorganisms in soil; associative and antagonistic effects among soil microorganisms.

Practicals: Isolation and enumeration of algae, protozoa, actinomycetes, cellulose decomposing microrganisms, autotrohic bacteria, slime moulds and fungi, Perfusion techniques to study biogeochemical changes (oxidation-reduction, solubization, activities symbiotic and free living ammonification, sulphur oxidizing bacteria, VA mycorrhiza, rhizosphere and phyllosphere microorganisms.

References

1) Soil /Microbiology 1995, Robert L. Tate II, Hohn Wiley & Sons, INC. New York. Ohn Wiley and Sons, INC. New York.

2) Introduction to soil microbiology Second Edition 1977, Martin Alexander honn wiley & Sons, New York

3) Soil Microbiology 2000, R.R. Mishra, CBS Publishers, New Delhi

AMB 511 INDUSTRIAL MICROBIOLOGY 1+1

Theory : Biofermentor. Production of wine, beer, lactic acid, acetic acid (vinegar), citric acid, antibiotics, enzymes, vitamins, single cell proteins. Vaccines. Bioagents and Biopesticides. Bioplastics and biopolymers: Microorganisms involved in synthesis of biodegradable plastics, other pigments, Biosensors: Development of biosensors to detect food contamination and environment pollution. Biomining: Coal, mineral and gas formation, prospecting for deposits of crude, oil and gas, recovery of minerals from low-grade ores.

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

AMB 512 BIOFERTILIZER TECHNOLOGY 1+1

Theory : Agriculturally important beneficial microorganisms – free living, symbiotic (rhizobial, actinorhizal) nodule formation, competitiveness and quantification of N2 fixed, associative and endophytic nitrogen fixers including cyanobacteria, taxonomic classification,. Phosphate solubilizing bacteria and fungi and mycorrhiza. Potash solubilizing /mobilizing microbes.Plant growth promoting rhizobacteria. Microbial biocontrol agents. Beneficial

microorganisms for recycling of organic waste and composting, Bioremediators and other related microbes. Other agriculturally important beneficial microorganisms - selection, establishment, competitiveness, crop productivity, soil and plant health. Large scale production of biofertilizers Different formulations of biofertilizers. Quality control of microbial inoculants. Marketing of biofertilizers .Methods of biofertilizer application.

Practical : Isolations of symbiotic, asymbiotic, associative nitrogen fixating bacteria. Development and production of efficient microorganisms, Determination of beneficial properties in important bacteria to be used as biofertilizer, Nitrogen fixing activity, P and K solubilization by microbes. Estimation of AM fungal spores and percent infection in roots. Testing for Indole acetic acid (IAA), GA, Cytokinins and siderophore production by beneficial microorganisms. Biofertilizer production and quality control.

AMB 513 BIOLOGY AND PRODUCTION OF MYCORRHIZAE (2+1)

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 inoculationmechanism of improved plant growth. Production of the VA mycorrhizae inoculums and its application. Vesicular-arbuscular mycorrhizae taxonomy pf the fungi, morphology and histology, quantification in plnat roots and in soil. Isolation, axenic and pot culture. Procedures for inoculation, plant response to colonizations. Physiology 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 inoculums; evaluation of plant responses to mycorrhizal inoculation Study tour to collect samples for isolation and identification of mycorrhizal fungi.

References:

1. The mycorrhizae Diversity, Ecology and Applications 2008, M. Tiwari & S.c. Sati (Auditors), Daya Publishing House Delhi
2. Fundamentals of mycorrhizal biology and Biotechnology 2002, Ramarao Pannuri, Agrotech Publishing Academy, Udaipur

AMB 515 FOOD MICROBIOLOGY (2+1)

Theory: Occurrence and role of microorganisms in food industry; primary sources of microorganisms found in food; intrinsic and extrinsic parameters of food affecting microbial growth; types of microorganism in foods like meats poultry, sea food, vegetables, and dairy products; assessing microbial load on food and food products, physical, chemical and immunological methods; microbial spoilage of different types of foods; fruits, vegetables, milk, meat, poultry and sea food; principles of food preservation; food preservation using chemical, irradiation, low temperature, high temperature and draying processes, aseptic packing materials; fermentation of food and related products; fermentation of pickles, sauerkraut, bread, idly and curd; fermentation of vinegar and lactic acid, microbiology of processed canned foods; microorganisms as food; single cell protein; food sanitation, indicator organism, coliform bacteria, food borne diseases and food poisoning; botulism, salmonellosis-gastroenteritis-food pathogens, *Clostridium perfringens, Vibrio haemolyticus, Campylobacter jejuni;* food processing plant sanitation, microbiological standards and guidelines, quality control and food laws.

Practicals: Examination of microorganisms on normal and spoiled fruits and vegetables, cereal products, sugar products, dried fruits and vegetables; use of food preservatives *viz.,* chemicals, irradiation, low and high temperature on the control of food borne microorganisms; microbial spoilage of canned and bottled food, meat and fish; diagnosis of spoilage of various foods; microbiological survey in utensils and processing plant; fermentation of lactic and vinegar; assessing the load of coliform bacteria and Salmonella as indicator organisms.

References

1. Food Microbiology 1967, W.C. Frazier, Mcgraw-Hill Book Company New York
2. Food Microbiology, Pelzar & Raid

AGRONOMY

COURSE LIST

AGR 505	AGROMETEOROLOGY AND CROP WEATHER FORECASTING	2+1
AGR 514	CROP GROWTH AND YIELD ANALYSIS	1+1

COURSE CONTENT

AGR 505 AGROMETEOROLOGY AND CROP WEATHER FORECASTING 2+1

Theory : Agro meteorology - aim, scope and development in relation to crop environment; composition of atmosphere, distribution of atmospheric pressure and wind. Characteristics of solar radiation; energy balance of atmosphere system; radiation distribution in plant canopies, radiation utilization by field crops; photosynthesis and efficiency of radiation utilization by field crops; energy budget of plant canopies; environmental temperature: soil, air and canopy temperature. Temperature profile in air, soil, crop canopies; soil and air temperature effects on plant processes; environmental moisture and evaporation: measures of atmospheric temperature and relative humidity, vapor pressure and their relationships; evapo-transpiration and meteorological factors determining evapotranspiration. Modification of plant environment: artificial rain making, heat transfer, controlling heat load, heat trapping and shading; protection from cold, sensible and latent heat flux, controlling soil moisture; monsoon and their origin, characteristics of monsoon; onset, progress and withdrawal of monsoon; weather hazards, drought monitoring and planning for mitigation. Weather forecasting in India – short, medium and long range; aerospace science and weather forecasting; benefits of weather services to agriculture, remote sensing; application in agriculture and its present status in India; atmospheric pollution and its effect on climate and crop production; climate change and its impact on agriculture.

Practical : Visit to agro-meteorological observatory to record sun-shine hours, wind velocity, wind direction, relative humidity, soil and air temperature, evaporation, precipitation and atmospheric pressure; Measurement of solar radiation outside and within plant canopy; Measurement/estimation of evapo-transpiration by various methods; Measurement/estimation of soil water balance; Rainfall variability analysis; Determination of heat-unit requirement for different crops; Measurement of crop canopy temperature; Measurement of soil temperatures at different depths; Remote sensing and familiarization with agro-advisory service bulletins; Study of synoptic charts and weather reports, working principle of automatic weather station; Visit to solar observatory.

AGR 514 CROP GROWTH AND YIELD ANALYSIS 1+1

Theory : Crop growth and development, Growth expressions in plants. Growth measurements. History and development of important growth indices and

forms of growth analysis in field crops. Genesis of crop yield, formation of yield components. Plant density and yield relationships in crops- density equations. The senescence of leaf, leaf area and leaf area duration, chlorophyll content, development of primordium, chloroplast and their relation to dry matter production and yield. Accumulation and distribution of dry matter-partition analysis of crop plants, contribution of each part to economic yield. Factors determining yields. Use of growth analysis technique to study variation in yield due to planting season, planting density, fertilizer treatment, other agronomic practices, light, temperature, water, growth substances, varietal differences. Crop response curves. Dynamics of crop growth and modeling.

Practical : Partitional analysis of dry matter production and accumulation in different crops. Patterns of nutrient contents and dry weight accumulation of whole plants (%) and in different parts. Dry matter accumulation (% of total) curves and their importance in crop growth and development of the plant. Methods of measuring leaf area and estimation of leaf production constant (factor) in different crops. Estimation of leaf area and leaf angle at different profiles in different crops. Estimation of dry matter production (g/plant) and accumulation (% to total). Estimation of LA/plant (cm^2), Leaf area index (LAI) and leaf area duration (LAD, days). Estimation of Absolute growth rate (AGR, g/plant/day), Daily rate of DM production and relative growth rate (RGR, g/day). Estimation of leaf area ratio (LAR), Relative growth rate of leaf (RGRL), leaf weight ratio (LWR) and Specific leaf area (SLA). Computation of growth indices for the given primary data and presentation of these through tables and graphs. Estimation of Net assimilation rate (NAR, g/dm^2/day by Gregory's method (Ea) and whitehead and Myers cough's method (E'a) and Crop growth rate (CGR, g/cm^2/day). Study on light transmission and radiation measurements in relation to canopy analysis studies (Co- efficient of solar energy utilization). Estimation of chlorophyll content in different crops and relating them to growth and yield thorough chlorophyll index. Computation of biological yield, harvest index (HI), Grain to leaf ratio and dry matter efficiency (DME). Study of relationship between growth and yield components in expression of ultimate yield in different crops. Working out crop response curves. Working out crop growth – modeling.

APICULTURE

COURSE LIST

API 507	HONEY AND BEE PRODUCTS	1+1
API 508	BEE POLLINATION AND CROP PRODUCTION	1+1

COURSE CONTENT

API 507 HONEY AND BEE PRODUCTS 1+1

Theory : Honey – categories and types, physical and chemical properties, harvesting, processing, storage and marketing of honey. Purity standard of honey, detection of adulteration, crystallization, fermentation and its prevention. Uses and value addition of honey; Composition, properties, production, processing, uses and marketing of other bee/hive products such as - Wax, pollen, propolis, royal jelly, bee venom.

Practical : Extraction and processing of honey, analysis of honey and its composition. Spoilage of honey and its prevention. Properties and sensory evaluation of honey from different sources. Mellisopalynological study of honey; study of quality standards of honey. Collection and purification of wax, propolis, royal jelly. Visit to honey processing plant and bee keepers societies in Karnataka.

API 508 BEE POLLINATION AND CROP PRODUCTION 1+1

Theory : Modes of pollination and its ecological significance. Assessment of pollination efficiency, pollination ecology, foraging behaviour of honey bees. Pollination of agricultural, horticultural, plantation and greenhouse crops. Managing bees for pollination. Case studies of bee pollination. Role of bees in hybrid seed production of crops. Moving bees to crops, pollination services, mechanical aids to pollination, economics of bee pollination, and problems in pollination. Pollination specialities.

Practical : Crop wise pollinator diversity, floral structure and pollinator efficiency. Quantification of forage resource in crops, determination of nectar sugar, pollen yield of different flower species. Assessment of the extent of cross pollination in selected crops. Study of bee attractants and repellents in relation to bee pollination. Bee fidelity. Assessment of yield and quality parameters in crops under bee pollination. Determining relative abundance of honey bee species in different crops. Pollination in relation to forager density. Training bees to exploit rich sources. Collection of pollinators from important horticultural and agricultural crops and submission.

CROP PHYSIOLOGY

COURSE LIST

CPH 502 PRINCIPLES OF PLANT PHYSIOLOGY – II 2+1
METABOLIC PROCESSES AND GROWTH REGULATION

CPH 508	MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION	1+1
CPH 512	EXPERIMENTAL TECHNIQUES IN PLANT PHYSIOLOGY	0+1
CPH 513	PHYSIOLOGY OF WOODY PLANTS	2+0

COURSE CONTENT

CPH 502 PRINCIPLES OF PLANT PHYSIOLOGY – II 2+1
METABOLIC PROCESSES AND GROWTH REGULATION

Theory : Photosynthesis, Translocation and the respiration as key processes regulating carbon metabolism and plant growth. Photosynthesis, its importance in bio productivity. Photochemical process – chloroplast, its structure, photochemical reactions, CO_2 reduction in Calvin cycle, supplementary pathway of C fixation in C_4 and CAM plants and its significance. Photorespiration and its relevance. Photosynthesis as a diffusive process, effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall). Translocation of photosynthates and its importance in sink growth. Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance. Nitrogen metabolism: inorganic nitrogen species (N_2, NO_3 and NH_3) and their reduction to amino acids, protein synthesis and nucleic acids. Lipid metabolism-Storage, protective and structural lipids. Biosynthesis of fatty acids, diacyl and triacyl glycerol, fatty acids of storage lipids. Secondary metabolites and their significance in plant defense mechanism. Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones (Auxins, gibberellins, cytokinins, ABA, ethylene etc). Biosynthesis of growth hormones, their metabolism and their physiological role, synthetic growth regulators, growth retardants. Apical dominance, senescence, fruit growth abscission. Photo morphogenesis: Photo receptors, phytochrome. Cryptochrome, physiology of flowering photoperiodism and vernalization.

Practical : Radiant energy measurements, separation and quantification of chlorophylls, O_2 evolution during photosynthesis. Measurement of gas exchange parameters, conductance's, photosynthetic rate, photorespiration, respiration rates, estimation of reducing sugars, starch. Estimation of NO3, free amino acids in the xylem exudates, quantification of soluble proteins. Bioassays for different growth hormones – Auxins, Gibberellins, Cytokinins, ABA and Ethylene. Demonstration of photoperiodic response of plants in terms of flowering.

CPH 508 MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION 1+1

Theory : Morphogenesis: The cellular basis of growth and morphogenesis cytodifferentiation. The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and cellular totipotency. Introduction to *in vitro* methods : Terms and definitions, Use of growth regulators, Beginning of *in vitro* cultures in our country (ovary and ovule culture, in vitro pollination and fertilization), Embryo culture, embryo rescue after wide hybridization and its application, Endosperm culture and production of triploids. Introduction to the processes of embryogenesis and organogenesis and their practical applications: Clonal Multiplication of elite species (micropropagation) – axillary bud, shoot tip and meristem culture. Haploids and their applications. Somaclonal variations and applications. Introduction to protoplast isolation: Principles and applications. Testing of viability of isolated protoplast. Various steps in the regeneration of protoplast. Somatic hybridization – an introduction, Various methods for fusing protoplast, chemical and electrical. Use of makers for selection of hybrid cells. Practical applications of somatic hybridization (hybrids vs cybrids). Use of plant cells, protoplast and tissue culture for genetic manipulation of plant : Introdiuction to *A. tumefaciens*. Tumour formation on plants using *A. tumefaciens* (Monocots vs Dicots), Root – formation using *A. rhizogenes.*

Practical : Tissue culture laboratory orientation, facilities required, glassware, stock preparation, media preparation, aseptic manipulation in tissue culture lab, explants preparation for aspetic inoculation. *In vitro* culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes; Effect of explant age on propagation potential, Effect of growth regulators auxin, cytokinins and ethlyne on callus induction, organogenesis; Somatic embryogenesis, Effect of growth conditions such as temperature and photoperiod on organogenesis, Single – cell suspension cultures.

CPH 512 EXPERIMENTAL TECHNIQUES IN PLANT PHYSIOLOGY 0+1

Practical : Quantification of hormone – immunoassay/physico-chemical methods. WUE-determination of water use efficiency by gravimetric approach. Stable isotopes-use in physiological investigations. Use of isotope materials (potential photosynthesis/protein synthesis). Purification, quantification of RuBisCO by ELISA using polyclonal antibodies. Gas exchange technique,

measurement of photosynthetic rates and dark respiration. Protein purification and isozyme analysis. Moisture / Termperature stress – methods to impose, quantification of the stress levels. Molecular aspects of stress response – stress responsive proteins, their expression – western and northern analysis. Stress measurement parameters (membrane integrity, chlorophyll stability index, osmolyte quantification, osmotic adjustment. TTC, *etc.,*). DNA extraction and determination of polymorphism-RAPD, RFLP, and AFLP. Real – time PCR, Flourimetry. RNA isolation. Reverse Northern. cDNA library. Fluorescence kinetics and their application in physiology.

CPH 513 PHYSIOLOGY OF WOODY PLANTS 2+0

Theory : Growth and development of horticultural and plantation crop species. Juvenility, shoot growth, types of shoots. Patterns of shoot growth, cambial growth and its regulation. Physiological aspects of pruning and dwarfing. Growth measurements. Water relations of tree species. Water uptake and transport. Concepts of transpiration ratio and water use efficiency. Sexual and asexual propagation. Root stock and scion interactions. Physiology of flowering in perennial species, photoperiodism and thermoperiodism. Physiological aspects of fruit crops, mango, banana, grapes, citrus, papaya and pineapple, etc. Physiological aspect of plantation crops coffee, tea, cardamom, coconut, pepper. NB species could be chosen based on the local importance.

ENVIRONMENTAL SCIENCE

COURSE LIST

EVS 502	BIODIVERSITY AND CONSERVATION	1+1
EVS505/AEC510/FOR506	*REMOTE SENSING AND GIS APPPLICATION IN BIODIVERSITY CONSERVATION*	*1+1*
EVS 511	GLOBAL CLIMATE CHANGE AND ENVIRONMENT	2+0

COURSE CONTENT

EVS 502 BIODIVERSITY AND CONSERVATION 1+1

Theory : Elements of Biodiversity - Measuring biodiversity - Species abundance - species diversity - number and difference - habitat distribution - Biodiversity through time - the fossil record - history of biodiversity - diversification - extinction -. Mapping biodiversity - Species -Area relationships - Local regional diversity relationships - Extremes of high and low diversity - Gradients in

biodiversity - latitudinal, altitudinal and depth gradients in biodiversity - Importance of biodiversity - Use value. Maintaining biodiversity - the scale of human enterprise - The Convention on Biological Diversity. Why conservation - Objectives and general measures for conservation and sustainable use -In -situ and Ex -situ Conservation Tropical forests and their conservation - Deforestation -The pressure on wildlife - conservation of species - species extinction - Genetic diversity in rare species - Conservation of ecosystems - Habitat conservation - Design and Maintenance of conservation areas - Conservation of the biosphere - Special projects for endangered species - Man and Biosphere programmes - Viable conservation.

Practical : Species abundance - species richness - interrelationships. Populations - growth regulation and interaction. Habitat distribution - Natural selection - Genetic variability in natural populations -Conservation -tropical forests -wildlife ecosystems - Endangered species -viable conservation.

EVS 505 REMOTE SENSING AND GIS APPPLICATION IN BIODIVERSITY CONSERVATION 1+1

Theory : Introduction to remote sensing, electromagnetic spectrum- physics of remote sensing, effects of atmosphere, spectral reflections of earth objects. GPS- introduction basic principles, definition of map, computer assisted cartography, hardware requirements, types of data. Spatial and non-spatial data. Raster and Vector data conversion, Geographic information system analysis and modeling, digital counter modeling, errors, elimination. GIS software packages, capabilities, creating base maps, raster and vector conversions. Digitizing- linking data files, tools for mapping and GIS. Use of GIS in policy and planning. Various platforms for data acquisitions, aerial photography, satellite sensors; optical, thermal and microwave. Different types of data products and their characteristics. Satellite data acquisitions. Storage and retrieval, visual interpretations, digital image processing.

Practical : Introduction to software's used in remote sensing and GIS Study of land use planning and equipments used in aerial photography. Study of scales of serial photography and interpretation. Case studies on application of satellite imageries and GIS.

EVS 511 GLOBAL CLIMATE CHANGE AND ENVIRONMENT 2+0

Theory : Issues on global climate change, Climate change and biodiversity, IPCC assessment on climate change and International conventions, El nino effect, Climatic fluctuations over India, climate change and global

desertification process, Ongoing efforts on climate change research. Greenhouse gases - CO_2, CH_4, NOx, CFCs etc. Greenhouse gases in atmosphere, global warming potential, source - sink ratios and atmospheric loading rates etc.. Mitigation options of greenhouse gases. CO_2 enrichment studies and plant response, O_3 depletion and CFC's , climate change mitigation in polar regions. Causes and control measures, Impact on different ecosystem. Role of mathematical models in predicting climate change and its impact on productivity and soil fertility.

FOOD SCIENCE AND NUTRITION

COURSE LIST

FSN 502	PRINCIPLES OF NUTRITION	3+0
FSN 503	FOOD ANALYSIS	1+2

COURSE CONTENT

FSN 502 PRINCIPLES OF NUTRITION 3+0

Theory : Functions, sources, requirements, digestion and absorption of carbohydrates; definition, composition, classification, functions and role of dietary fibre in various physiological disorders. Basis of requirement, functions, sources, digestion and absorption of protein; Methods of assessing protein quality. Basis of requirement, functions, sources, digestion, absorption and deficiency disorders of lipids; essential fatty acids. Requirements, functions, sources, deficiencies and toxicities, fat and water soluble vitamins. Requirement, functions, sources, deficiency, toxicity and factors affecting absorption and utilization of macro and micro minerals. Water balance; acid and base balance.

FSN 503 FOOD ANALYSIS 1+2

Theory : Familiarization to terms and calculations used in preparation of various standard solutions. Sample and sampling techniques. Principles, techniques and applications of colorimetric, spectrophotometer and atomic absorption spectrophotometer. Principles, techniques and applications of spectrophotometer, fluorimetry, flame photometry and electrophoresis. Principles techniques and application of chromatography (paper chromatography, TLC,GLC, HPLC). Introduction to animal assay.

Practical : Handling of equipment and instruments; preparation of samples, solutions and buffers; quantitative estimation of proximate principles, minerals and vitamins by use of colorimetry, flame photometry, UV spectrophotometer;

chromatography, atomic absorption spectrophotometer and photofluorometry, analysis of antinutritional factors; estimation of protein and starch digestibility; fractionation of protein; food adulteration.

GENETICS AND PLANT BREEDING

COURSE LIST

GPB 507	HETEROSIS BREEDING	2+0
GPB 513	BREEDING FOR QUALITY TRAITS	1+0
GPB 515	GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE	1+0
GPB 516	PLANT GENETIC RESOURCES UTILIZATION	1+0
GPB 517	PLANT VARIETY PROTECTION AND BIOSAFETY IN THE MANAGEMENT OF TRANSGENCIS	1+0

COURSE CONTENT

GPB 507 HETEROSIS BREEDING 2+0

Theory: Historical aspect of heterosis - Nomenclature and definitions of heterosis - Heterosis in natural population and inbred population; Evolutionary aspects - Genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops. Pre Mendelian and Post-Mendelian ideas - Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; - Evolutionary concepts of heterosis. Prediction of heterosis from various crosses- Inbreeding depression, frequency of inbreeding and residual heterosis in F2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.Relationship between genetic distance and expression of heterosis – case studies; Divergence and Genetic Distance analyses-morphological and molecular genetic distance in predicting heterosis, Development of heterotic pools in germplasm/ genetic stocks and inbreds, their improvement for increasing heterosis. Types of male sterility and use in heterosis breeding; Maintenance, transfer and restoration of different types of male sterility; Use of self incompatibility in development of hybrids; Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis-maintenance breeding of parental lines in hybrids.

Fixation of heterosis in self, cross and often cross pollinated crops, asexually/ clonally propagated crops; Male sterile line creation and diversification in self

pollinated, cross pollinated and asexually propagated crops; problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid. Organellar heterosis and complementation - Creation of male sterility through genetic engineering and its exploitation in heterosis. Heterosis breeding in sunflower, wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops.

GPB 513 BREEDING FOR QUALITY TRAITS 1+0

Theory : Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Nutritional improvement - A human perspective - Breeding for grain quality parameters in rice and its analysis - Golden rice and aromatic rice – Breeding strategies, achievements and application in Indian context - Molecular basis of quality traits and their manipulation in rice - Post harvest manipulation for quality improvement. Breeding for baking qualities in wheat; Characters to be considered and breeding strategies - Molecular and cytogenetic manipulation for quality improvement in wheat - Breeding for quality improvement in barley and oats. Breeding for quality improvement in Sorghum and pearl millet; Quality protein maize – Concept and breeding strategies – Breeding for quality improvement in Ragi and forage crops - Genetic resource management for sustaining nutritive quality in crops. Breeding for quality in pulses - Breeding for quality in groundnut, sesame, sunflower and minor oilseeds – Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality improvement in cotton. Genetic engineering protocols for quality improvement – Achievements made - Value addition in crops; Classification and importance – Nutritional genomics and Second generation transgenics.

GPB 515 GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE 1+0

Theory : History and importance of germplasm exploration; Distribution and extent of prevalent genetic diversity; Phyto-geographical regions/ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora. Concept of population and gene pool; Variations in population and their classification; Gene frequencies in populations, rare and common alleles; Gene pool sampling in self and cross pollinated and vegetatively propagated species; Non-selective, random and selective sampling strategies; Strategies and logistics of plant exploration and collection; Coarse and fine grid surveys. Ethnobotanical aspects of PGR; Crop botany, farming systems, collecting wild relatives of crop plants; Collection and preservation of specimens; Importance and use of herbaria and

preparation of herbarium specimens. Post-exploration handling of germplasm collections; Present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum, sesame, *Brassica*, okra, eggplant, cotton, mango etc; approaches for collection including indigenous knowledge. History, principles, objectives and importance of plant introduction; Prerequisites, conventions, national and international legislations and policies on germplasm collection and exchange; Documentation and information management; Plant quarantine-introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India; Pest risk analysis, pest and pathogen information database; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses, phytoplasma etc.). Symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities; Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust.Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

GPB 516 PLANT GENETIC RESOURCES UTILIZATION 1+0

Theory : Historical perspective; Taxonomical classification of cultivated plants; Regions of crop-plant diversity; Gene pool: primary, secondary and tertiary; Centres of origin and diversity; Basic genetic resources, derived genetic resources and transgenes; Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloguing of PGR; Plant quarantine principles and phytosanitory certification; Germplasm introduction and exchange; Principles of *in vitro* and cryopreservation; Germplasm conservation - *in situ*, *ex situ* and on-farm ; short, medium, long -term conservation strategies for conservation of orthodox and non-orthodox seed, vegetatively propagated crops; registration of plant genetic resources; PGR database management, description, national and international mechanism for PGR management; Plant genetic resources for food and agriculture (PGRFA), PGR access and benefit sharing; IPR, PBR, UPOV and CBD issues and consequences; Farmers' rights and privilege; Visit to Gene Bank/National/ Regional Research Centres.

GPB 517 PLANT VARIETY PROTECTION AND BIOSAFETY IN THE MANAGEMENT OF TRANSGENCIS 1+0

Theory : Current status of plant variety protection in other countries and the existing scenario in India. Historical perspectives leading to the present status - Plant protection Act (PPA) of 1930 - Diamond *vs* Chakravarthy case. The Plant variety Protection Act 1970. Revisions of UPOV from time to time. Plant Breeders Rights - Obligations and modalities followed in conferring it. DUS criteria. Essentially derived varieties. Salient features of the PBR system in USA, Australia and Japan. IPR regimes under the GATT agreement. Suigeneris system of protection of crop varieties. Registration of novel genotypes. Farmers right on indigenous knowledge & conservation - benefit sharing. International understanding on the Conservation of Biological Diversity. Role of CGIAR system in the germplasm exchange. Patent filing-opposition-retrieval procedures. Handling of transgenic material by public & private institutes, protocols to be followed and Biosafety considerations. Regulatory issues, Cartagena Protocol.

PLANT BIOCHEMISTRY

COURSE LIST

BCM 501	BASIC BIOCHEMISTRY	2+1
BCM 505	BIOCHEMICAL TECHNIQUES	1+2

COURSE CONTENT

BCM 501 BASIC BIOCHEMISTRY 2+1

Theory : Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid-base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers. Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids. Structure and biological functions of vitamins; Enzymes: classification and mechanism of action, regulation, factors affecting enzyme action. Hormones: animals, plants and insects.Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics. Metabolism of carbohydrates, photosynthesis and respiration, oxidative phosphorylation, lipids, proteins and nucleic acids. DNA replication, transcription and translation; recombinant DNA technology

Practical: Preparation of standard and buffer solutions, Extraction and estimation of sugars, Amino acids, Estimation of Proteins by Lowry's method,

Estimation of DNA and RNA by diphenylamine and orcinol methods. Estimation of Ascorbic acid. Separation of biomolecules by TLC and Paper chromatography.

BCM 505 BIOCHEMICAL TECHNIQUES 1+2

Theory : Chromatographic and electrophoretic methods of separation, Principles and applications of Paper, Thin layer & HPTLC, Gas, Gas-liquid and Liquid chromatography, HPLC and FPLC; Paper and gel electrophoresis, Different variants of polyacrylamide gel electrophoresis (PAGE) like native and SDS-PAGE, 2D-PAGE, capillary electrophoresis. Spectrophotometry: Principles and applications; UV-Visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy. Hydrodyanmic methods of separation of biomolecules such as viscosity and sedimentation- their principles, variants and applications. Tracer techniques in biology: Concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of á, â and ã emitters, scintillation counters, ã-ray spectrometers, autoradiography, applications of radioactive tracers in biology, principles and applications of phosphor imager.

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

SERICULTURE

COURSE LIST

SER 506 NON-MULBERRY SERICULTURE 1+1

COURSE CONTENT

SER 506 NON-MULBERRY SERICULTURE 1+1

Theory : Scope of non-mulberry sericulture in India. Global distribution of non-mulberry silkworm species and their breeds. Non-insect silk fauna and their use. Grainage operations and rearing methods including improved rearing techniques for tropical tasar, temperate tasar, muga and eri silkworms. *Anaphe* culture. Natural enemies and their management of non-mulberry silkworms

and economics of tasar and eri cultures. Exploitation of cultivated castor / tapioca for sericulture. Lesser known silkworm species, their distribution, host plants and their economic importance.

Practical : Study of life history of eri, tasar and muga silkworms. Host plants of eri, tasar and muga silkworms. Pests of host plants of eri, muga and tasar silkworms. Eri silkworm rearing equipments and disinfection. Grainage operations in eri DFLs preparation. Effect of mating duration on fecundity and hatchability. Effect of different strata on egg laying. Eri egg incubation and brushing. Rearing of eri silkworms on different host plants. Instar wise leaf requirements for eri silkworm. Diseases and pests of eri silkworm. Spinning, harvesting and grading of cocoons. Cocoon characters of eri, tasar and muga silkworms. Economics of ericulture.

FORESTRY (PLANTATION TECHNOLOGY)

COURSE LIST

FOR 505	FOREST ECOLOGY AND BIODIVERSITY CONSERVATION	2+1
FOR 509	TREE IMPROVEMENT	1+1
FOR 517	ENERGY PLANTATIONS AND BIO-FUELS	1+1

COURSE CONTENT

FOR 505 FOREST ECOLOGY AND BIODIVERSITY CONSERVATION 2+1

Theory : Advanced topics in forest ecology including forest population, forest community dynamics, forest community structure and analysis, forest productivity on a global scale, ecology of forest landscapes spatial heterogeneity; Hierarchy issues in ecology. Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserve). Global warming and forests. Green House Effect and its consequences. Ozone depletion. Conservation laws and acts. Forest genetics resources of India: timber and non timber species. Survey exploration and sampling strategies. Biological diversity: concept, types, distribution, magnitude and Benefits. Its significance to sustainable use. Inventorying, mapping and monitoring biodiversity. Loss of Biodiversity: Patterns, Causes and Mitigation. Global Climate change and forests. Green House Effect and its consequences. Ozone depletion. Documentation and evaluation of forests genetic resources (FGR), *in situ* and *ex situ* conservation of gene resources. Biological diversity and its significance to sustainable use. Handling and storage of FGR. Intellectual property rights. Quarantine laws and FGR exchange. Principles of Conservation biology. Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserve). IUCN categories and examples. Conservation laws and acts. Survey exploration and sampling strategies.

Practical : Study of forest community structure and its successional status, Estimation of productivity of forest ecosystem, Trip to different regions of the state to study forest vegetation, Collection and preservation of specimen, Methods of vegetation analysis, Measurement of biomass and productivity, Quantification of litter production and decomposition, Visit to national parks, wildlife sanctuaries, botanical gardens and arboretum.

FOR 509 TREE IMPROVEMENT 1+1

Theory : General concept of forest tree breeding, tree improvement and forest genetics. Reproduction in forest trees, dimorphism pollination mechanisms. Pollen dispersion distances, pollinators and their energetics. Attractants for pollinators. Pollen handling forced flowering for seed orchard manipulation. Pollination mechanisms. Variation in trees importance and its causes. Natural

variation as a basis for tree improvement. Geographic variations – Ecotypes, clines, races and land races. Seed, seed formation, dispersal, storage, stratification and seed dormancy. Selective breeding methods- mass, family, within family, family plus within family. Plus tree selection for wood quality, disease resistance and agroforestry objectives. Selection strategies and choice of breeding methods and progress in selective breeding in forest trees. Indirect selection for biotic and abiotic stresses. Progeny and clone testing. Seed orchards – type, functions and importance. Estimating genetic parameters and genetic gain. Heterosis breeding: inbreeding and hybrid vigour. Manifestation and fixation of heterosis. Species and racial hybridization. Indian examples – teak, sal, shisham, eucalypts, acacias, pines and poplars. Polyploidy, aneuploidy and haploidy in soft and hard wood species. Induction of polyploidy. Hardy-weinberg law, null hypothesis, Wohlund's Principle. Biotechnology in tree improvement. Mutation breeding. Marker assisted selection and examples. Economics of tree breeding. Seed certification.

Practical : Floral biology, modes of reproduction and modes of pollination in forest trees. Estimating pollen viability. Controlled pollination and pollen handling. Manipulation of flowering through hormones. Identification of ecotypes, races, and land-races in natural forest. Visit to species, provenance and progeny trials. Selection of superior phenotypes. Marking of candidate trees, plus trees and elite trees. Visit to seed orchards. Comparison of parents and their putative hybrids. Induction of polyploidy through colchicine treatment. Practical : Mateing designs in Forestry and progeny testing. Design and evaluation of tree improvement experiments.

FOR 517 ENERGY PLANTATIONS AND BIO-FUELS 1+1

Theory : Introduction and advantages of energy plantations. Energy and biomass consumption patterns in India. Environmental impacts of biomass energy. Assessment of bio-energy programmes in India. Power generation from energy plantation, producer gas. High Density Energy Plantations (HDEP). Land and biomass availability for sustainable bio energy. Impact of energy efficiency in power sector. Need for research and development on environment friendly and socio economical relevant technologies. Energy from plants-problems and prospects. Petro-crops. Criteria for evaluation of different species for energy plantation. Recent energy technologies in the product of bio-fuels.

Practical : Identification of important fuel woods and petro-crops. Study on different bio fuels used in India. Determination of calorific value, moisture and ash content in biomass Study of energy consumption pattern in rural and urban areas through survey. Visit to nearby Bio-energy units.

AGRICULTURAL STATISTICS

COURSE LIST

HST/AST 501	STATISTICAL METHODS FOR APPLIED SCIENCES	1+1
HST/AST 502	EXPERIMENTAL DESIGNS	1+1

HST 501 STATISTICAL METHODS FOR APPLIED SCIENCES (1+1)

Theory : Review of Probability, Discrete and continuous probability distributions: Binomial, Poisson, Normal distribution, distributions and their applications and fitting of distributions. Sampling Distribution - means and proportions, Std. error. Introduction to theory of estimation and confidence-intervals. Testing of Hypothesis, type I and type-II errors. Tests of significance based on Normal, student F distributions and chi-square. Large sample theory. Correlation and regression. Simple linear regression model, estimation of parameters Predicted values. Test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Analysis of variance technique. One way analysis of variance. Two way analysis with one and multiple observations

Practical: Solving problems on above topics

HST 502 EXPERIMENTAL DESIGNS (1+1)

Theory : Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control. Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design. Factorial experiments, (symmetrical as well as asymmetrical). Orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment. Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations

Practical : Uniformity trial data analysis, formation of plots and b locks, FAirfielod Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Trans formation of data.

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