

*Detail Course Structures & Syllabus*

**For**

**Ph.D. degree programme under different  
disciplines of Horticulture**

- Fruit Science
- Vegetable Science
- Floriculture and Landscape Architecture
- Plantation, Spices, Medicinal & Aromatic Crops



**Department of Horticulture  
SASRD, Medziphema Campus, NU  
Medziphema – 797 106**

## Ph.D in HORTICULTURE( Fruit Science)

### *Compulsory courses*

Course No.	Titles	Credit hr.
FSC-601	Advances in breeding of fruit crops	2+1
FSC-602	Advances in production of tropical and temperate fruit crops	2+1
FSC-603	Advances in growth regulation of fruit crops	2+1
FSC-606	Advances in production of subtropical and dryland fruit production	2+1
FSC-607	INM in horticultural crops	2+1
FSC-691	Doctoral seminar – I	0+1
FSC-692	Doctoral seminar – II	0+1
FSC-699	Doctoral research	0+45

### *Optional courses*

Course No.	Titles	Credit hr.
FSC-604	Genomic and bioinformatics in horticulture	2+1
FSC-605	Biotic and abiotic stress management in horticultural crops	2+1

### **FSC-601 ADVANCES IN BREEDING OF FRUIT CROPS (2+1)**

#### **Theory**

Evolutionary mechanisms, adaptation and domestication, Genetic resources, cytogenetics, cytomorphology, chemotaxonomy, genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits, recent advances in crop improvement efforts- introduction and selection, chimeras, apomixis, clonal selections, intergeneric, interspecific and intervarietal hybridization, mutation and polyploid breeding, breeding for resistance to biotic and abiotic stresses, breeding for improving quality, molecular and transgenic approaches in improvement of selected fruit crops.

#### **Crops**

UNIT I : Mango, Banana, Papaya

UNIT II: Grapes, Citrus, Guava, Sapota, Pineapple, Avocado

UNIT III : Apple, Pear, Plums, Peaches, Apricot, Cherries and Strawberry

#### **Practical**

Description and cataloguing of germplasm, pollen viability tests, pollen germination, isozyme techniques, survey and clonal selection, observations on pest, disease and stress reactions in inbreds and hybrids, use of mutagens and colchicine for inducing mutation and ploidy changes, practices in different methods of breeding fruit crops and in-vitro breeding techniques.

## **FSC-602: ADVANCES IN PRODUCTION OF TROPICAL AND TEMPERATE FRUIT CROPS (2+1)**

### **Theory**

National and International scenario in fruit production, Recent advances in propagation - root stock influence, planting systems, High density planting, crop modeling, Precision farming, precision support systems - aspects of crop regulation- physical and chemical regulation effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Total Quality Management (TQM) an overview

### **Crops**

UNIT I : Mango, Banana, Papaya, Citrus, Guava, Sapota, Pomegranate

UNIT II : Apple, Pear, Plum, Strawberry, Peach, Apricot, Cherries and nut crops

### **Practical**

Survey of existing fruit cropping systems and development of a model cropping system, Estimating nutrient deficiency- estimation of water use efficiency, soil – crop response correlations, practices in plant growth regulation, studying physiological and biochemical responses, quality analysis. Visit to tropical and temperate orchards, Project preparation for establishing commercial orchards.

## **FSC-603: ADVANCES IN GROWTH REGULATION OF FRUIT CROPS (2+1)**

### **Theory**

UNIT I : Eco-physiological influences on growth and development of fruit crops flowering, fruit set- Crop load and assimilate partitioning.

UNIT II : Root and canopy regulation, study of plant growth regulators in fruit culture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants.

UNIT III : Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, canopy management for orchards.

UNIT IV : Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production.

UNIT V : PGR in flower drop and thinning, fruitset and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, molecular approaches in crop growth regulation – an overview.

### **Practical**

Root- shoot studies, quantifying the physiological and biochemical effects of physical and chemical growth regulation, bioassay and isolation through chromatographic analysis for auxins,

gibberellins, experiments on growth regulation during propagation, dormancy, flowering, fruitset and fruit development stages.

## **FSC-604: GENOMICS AND BIOINFORMATICS IN HORTICULTURE (2+1)**

### **Theory**

UNIT I : Primer on bioinformatics and computational genomics, database fundamentals – biological databases, horticultural genome and protein databases, functional genomics.

UNIT II : Dynamic Programming Sequence Alignment, BLAST search engine, FASTA search engine, Microarrays- Microarray Clustering and Classification, Terminologies and Ontologies - EcoCYC knowledge base of E. Coli metabolism - Description of UMLS Semantic Network.

UNIT III : Multiple Sequence Alignment, MSA algorithm descriptions, ClustalW, 1D Motifs, Algorithms and Databases, methods for sequence weighting, BLOCKS database, Making BLOCK motifs, PROSITE database, 3D structure alignment, SCOP, DALI, LOCK, MUSTA algorithm for geometric hashing and multiple alignment.

UNIT IV : Hidden Markov models , Molecular energetics and dynamics , Protein structure prediction, Genetic networks - Modeling and Simulation of Genetic Regulatory Systems- KEGG database of genes and gene pathways/networks - EcoCYC database of metabolic pathways in E. Coli - EGF-signal pathway modeling, Gene finding algorithms – Genome Annotation Assessment Project for Arabidopsis, Comparative genomics algorithms, Genome Alignment.

UNIT V : 3Dstructure computations, NMR, Xtallography, NMR Structure Determination, X-ray Crystallography Structure Determination, Distance Geometry Description, RNA secondary structure, Molecular Modeling and Drug discovery programs.

UNIT VI : Phylogenetic algorithms - Treebase database of phylogenetic information for plants mostly, Tree of Life Page, Samples from the Tree of Life, Ribosomal Database Project, Natural Language Processing, Proteomics, 3D Motifs, Applications and Integration with Horticulture, Final Thoughts.

### **Practical**

Computers, Operating systems and Programming languages, Internet Resources, Horticultural Genome and Protein Databases, BLAST/RNA Structure, Sequence Alignment, Microarray Data Analysis, Ontology, MSA, HMMs, Identification of Functional Sites in Structures, Protein Structure Prediction - Phylogenetics - Gene Finding - Molecular Modeling and Drug Discovery Software – Assignments.

## **FSC-605: BIOTIC AND ABIOTIC STRESS MANAGEMENT IN HORTICULTURAL CROPS (2+1)**

### **Theory**

UNIT I : Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.).

UNIT II : Pollution - increased level of CO<sub>2</sub>, industrial wastes, impact of stress in horticultural crop production, stress indices, physiological and biochemical factors associated with stress, horticultural crops suitable for different stress situations.

UNIT III : Crop modeling for stress situations, cropping system, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stress and their impact on crop growth and productivity.

UNIT IV : Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers.

UNIT V : Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, cropping systems, stability and sustainability indices.

### **Practical**

Seed treatment / hardening practices, container seedling production, analysis of soil moisture estimates (FC, ASM, PWP), analysis of plant stress factors, RWC, chlorophyll fluorescence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate etc. under varied stress situations, influence of stress on growth and development of seedlings and roots, biological efficiencies, WUE, solar energy conversion and efficiency, crop growth sustainability indices, economics of stress management, visit to orchards and water shed locations.

## **FSC-606: ADVANCES IN PRODUCTION OF SUBTROPICAL AND DRYLAND FRUIT PRODUCTION (2+1)**

### **THEORY**

National and International scenario in fruit production, Recent advances in propagation - root stock influence, planting systems, High density planting, crop modeling, Precision farming, aspects of crop regulation- physical and chemical regulation effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Total quality management(TQM) – an overview.

### **Crops**

UNIT I: Litchi, pineapple, passionfruit, kiwifruit, strawberry, garcinia

UNIT II: Bael, wood apple, aonla , pomegranate, ber, jamun, phalsa

### **Practical**

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to subtropical, dryland orchards, Project preparation for establishing commercial orchards.

### **FSC-607 : INM IN HORTICULTURAL CROPS (2+1)**

#### **Theory**

Soil reaction and its relation with growth and cropping of different horticultural crops. Means to increase the nutrient use efficiency. Role of mycorrhiza in nutrition of horticultural crops. Fertilizer placement practices. Critical leaf nutrient content at different stages of growth, yield and nutrient content, removal of nutrients by crops. Micronutrients in horticultural crops- role and effect. Site specific nutrient management. Integrated nutrient management. Influence of rootstock in nutrients uptake.

#### **Practical**

Studies on the deficiency symptoms of major fruits, vegetables and plantation crops. Nutrition study by sand culture techniques. Estimation of major and micronutrients of leaf and shoot. Leaf nutrient standards using DRIS norms. Yield forecasting following the leaf nutrient standards. Use of isotopes for study of nutrient mobility in the plant.

## Ph.D in HORTICULTURE( Vegetable Science)

### *Compulsory courses*

Course No.	Titles	Credit hr.
VSC-601	Advances in vegetable production	2+1
VSC-602	Advances in breeding of vegetable crops	2+1
VSC-603	Protected cultivation of vegetable crops	1+1
VSC-604	Biotechnology of vegetable crops	1+1
VSC-607	INM in horticultural crops	2+1
VSC-691	Doctoral seminar – I	0+1
VSC-692	Doctoral seminar – II	0+1
VSC-699	Doctoral research	0+45

### *Optional courses*

Course No.	Titles	Credit hr.
VSC-605	Seed certification, processing and storage of vegetable crops	1+1
VSC-606	Biotic and abiotic stress management in horticultural crops	2+1
VSC-608	Genomics and bioinformatics in horticulture	2+1

### **VSC-601: ADVANCES IN VEGETABLE PRODUCTION (2+1)**

#### **Theory**

Present status and prospects of vegetable cultivation; nutritional and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies, disorders and correction methods; different cropping systems; mulching; containerized culture for year round vegetable production; low cost polyhouse; net house production; crop modeling, organic gardening; vegetable production for pigments, export and processing of:

UNIT I : Tomato, brinjal, chilli, sweet pepper and potato

UNIT II : Cucurbits, cabbage, cauliflower and knol-khol

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

UNIT IV : Carrot, beet root and radish

UNIT V : Sweet potato, tapioca, elephant foot yam and taro

#### **Practical**

Seed hardening treatments; practices in indeterminate and determinate vegetable growing and organic gardening; portraits and ball culture; diagnosis of nutritional and physiological disorders; analysis of physiological factors like anatomy; photosynthesis; light intensity in different cropping situation; assessing nutrient status, use of plant growth regulators; practices in herbicide application; estimating water requirements in relation to crop growth stages, maturity indices;

dryland techniques for rainfed vegetable production; production constraints; analysis of different cropping system in various situation like cold and hot set; vegetable waste recycling management; quality analysis; marketing survey of the above crops; visit to vegetable and fruit malls and packing houses.

## **VSC-602: ADVANCES IN BREEDING OF VEGETABLE CROPS (2+1)**

### **Theory**

Evolution, distribution, cytogenetics, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, interspecific and inter-generic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, *in vitro* breeding; breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for pest, disease, nematode and multiple resistance of:

UNIT I : Tomato, brinjal, chilli, sweet pepper and potato

UNIT II : Cucurbits, Cabbage, cauliflower and knol-khol

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

UNIT IV : Carrot, beet root and radish

UNIT V : Sweet potato, tapioca, elephant foot yam and taro

### **Practical**

Designing of breeding experiments, screening techniques for abiotic stresses, screening and rating for pest, disease and nematode resistance, estimation of quality and processing characters, screening for-quality improvement, estimation of heterosis and combining ability, induction and identification of mutants and polyploids, distant hybridization and embryo rescue techniques.

## **VSC-603: PROTECTED CULTIVATION OF VEGETABLE CROPS (1+1)**

### **Theory**

Crops: Tomato, capsicum, cucumber, melons and lettuce

UNIT I : Importance and scope of protected cultivation of vegetable crops; principles used in protected cultivation, energy management, low cost structures; training methods; engineering aspects.

UNIT II : Regulatory structures used in protected structures; types of greenhouse/polyhouse/nethouse, hot beds, cold frames, effect of environmental factors, *viz.* temperature, light, CO<sub>2</sub> and humidity on growth of different vegetables, manipulation of CO<sub>2</sub>, light and temperature for vegetable production, fertigation.



UNIT III : Nursery raising in protected structures like poly-tunnels, types of benches and containers, different media for growing nursery under cover.

UNIT IV : Regulation of flowering and fruiting in vegetable crops, technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, training and staking in protected crops, varieties and hybrids for growing vegetables in protected structures.

UNIT V : Problem of growing vegetables in protected structures and their remedies, insect and disease management in protected structures; soil-less culture, use of protected structures for seed production.

### **Practical**

Study of various types of structures, methods to control temperature, CO<sub>2</sub> light, media, training and pruning, maintenance of parental lines and hybrid seed production of vegetables, fertigation and nutrient management, control of insect-pests and disease in greenhouse; economics of protected cultivation, visit to established green/polyhouse/net house/shade house in the region.

## **VSC-604: BIOTECHNOLOGY OF VEGETABLE CROPS (1+1)**

### **Theory**

Crops: Tomato, eggplant, hot and sweet pepper, potato, cabbage, cauliflower, tapioca, onion, cucurbits.

UNIT I : *In vitro* culture methods and molecular approaches for crop improvement in vegetables, production of haploids, disease elimination in horticultural crops, micro grafting, somoclones and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, *in vitro* production of secondary metabolites.

UNIT II : Protoplast culture and fusion; construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in vitro* conservation.

UNIT III : *In vitro* mutation for biotic and abiotic stresses, recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology.

UNIT IV : Quality improvement, improvement for biotic and abiotic stresses, transgenic plants.

UNIT V : Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements, problems and future thrusts in horticultural biotechnology.

### **Practical**

Establishment of axenic explants, callus initiation and multiplication, production of suspension culture, cell and protoplast culture, fusion, regeneration and identification of somatic hybrids and cybrids; Identification of embryonic and non-embryonic calli, development of cell lines; *in vitro* mutant selection for biotic and abiotic stresses, *In vitro* production and characterization of secondary metabolites, isolated microspore culture, isolation and amplification of DNA, gene transfer methods, molecular characterization of transgenic plants.

## **VSC-605: SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE CROPS (1+1)**

## **Theory**

UNIT I : Seed certification, objectives, organization of seed certification, minimum seed certification standards of vegetable crops, field inspection, specification for certification.

UNIT II : Seed processing, study of seed processing equipments seed cleaning and upgrading, Seed packing and handling, equipment used for packaging of seeds, procedures for allocating lot number.

UNIT III : Pre-conditioning, seed treatment, benefits, types and products, general principles of seed storage, advances in methods of storage, quality control in storage, storage containers, seed longevity and deterioration, sanitation, temperature and relative humidity control.

UNIT IV : Seed testing; ISTA rules for testing, moisture, purity germination, vigor test, seed sampling, determination of genuineness of varieties, seed viability, seed health testing; seed dormancy and types of dormancy, factors responsible for dormancy.

UNIT V : Seed marketing, demand forecast, marketing organization, economics of seed production; farmers' rights, seed law enforcement, seed act and seed policy.

## **Practical**

Seed sampling, purity, moisture testing, seed viability, seed vigor tests, seed health testing, seed cleaning, grading and packaging; handling of seed testing equipment and processing machines; seed treatment methods, seed priming and pelleting; field and seed inspection, practices in rouging, seed storage, isolation distances, biochemical tests, visit to seed testing laboratories and processing plants, mixing and dividing instruments, visit to seed processing unit and warehouse visit and know about sanitation standards.

## **VSC-606: BIOTIC AND ABIOTIC STRESS MANAGEMENT IN HORTICULTURAL CROPS (2+1)**

### **Theory**

UNIT I : Environmental stress and its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress; root stock, use of wild species, use of antitranspirants.

UNIT II : Mechanism and measurements of tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

UNIT III : Soil-plant-water relations under different stress conditions in vegetable crops production and their management practices.

UNIT IV : Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

UNIT V : Techniques of vegetable growing under high and low temperature conditions, use of chemicals in alleviation of different stresses.

## **Practical**

Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops, measurement of tolerance to various stresses in vegetable crops, short term experiments on growing vegetable under water deficit, water-logging, salinity and sodicity, high and low temperature conditions, and use of chemicals for alleviation of different stresses.

## **VSC-607 : INM IN HORTICULTURAL CROPS (2+1)**

### **Theory**

Soil reaction and its relation with growth and cropping of different horticultural crops. Means to increase the nutrient use efficiency. Role of mycorrhiza in nutrition of horticultural crops. Fertilizer placement practices. Critical leaf nutrient content at different stages of growth, yield and nutrient content, removal of nutrients by crops. Micronutrients in horticultural crops- role and effect. Site specific nutrient management. Integrated nutrient management. Influence of rootstock in nutrients uptake.

### **Practical**

Studies on the deficiency symptoms of major fruits, vegetables and plantation crops. Nutrition study by sand culture techniques. Estimation of major and micronutrients of leaf and shoot. Leaf nutrient standards using DRIS norms. Yield forecasting following the leaf nutrient standards. Use of isotopes for study of nutrient mobility in the plant.

## **VSC-608: GENOMICS AND BIOINFORMATICS IN HORTICULTURE (2+1)**

### **Theory**

UNIT I : Primer on bioinformatics and computational genomics, database fundamentals – biological databases, horticultural genome and protein databases, functional genomics.

UNIT II : Dynamic Programming Sequence Alignment, BLAST search engine, FASTA search engine, Microarrays- Microarray Clustering and Classification, Terminologies and Ontologies - EcoCYC knowledge base of E. Coli metabolism - Description of UMLS Semantic Network.

UNIT III : Multiple Sequence Alignment, MSA algorithm descriptions, ClustalW, 1D Motifs, Algorithms and Databases, methods for sequence weighting, BLOCKS database, Making BLOCK motifs, PROSITE database, 3D structure alignment, SCOP, DALI, LOCK, MUSTA algorithm for geometric hashing and multiple alignment.

UNIT IV : Hidden Markov models , Molecular energetics and dynamics , Protein structure prediction, Genetic networks - Modeling and Simulation of Genetic Regulatory Systems- KEGG database of genes and gene pathways/networks - EcoCYC database of metabolic pathways in E. Coli - EGF-signal pathway modeling, Gene finding algorithms – Genome Annotation Assessment Project for Arabidopsis, Comparative genomics algorithms, Genome Alignment.

UNIT V : 3Dstructure computations, NMR, Xtallography, NMR Structure Determination, X-ray Crystallography Structure Determination, Distance Geometry Description, RNA secondary structure, Molecular Modeling and Drug discovery programs.

UNIT VI : Phylogenetic algorithms - Treebase database of phylogenetic information for plants mostly, Tree of Life Page, Samples from the Tree of Life, Ribosomal Database Project, Natural

Language Processing , Proteomics, 3D Motifs, Applications and Integration with Horticulture, Final Thoughts.

### **Practical**

Computers, Operating systems and Programming languages, Internet Resources, Horticultural Genome and Protein Databases, BLAST/RNA Structure, Sequence Alignment, Microarray Data Analysis, Ontology, MSA, HMMs, Identification of Functional Sites in Structures, Protein Structure Prediction - Phylogenetics - Gene Finding - Molecular Modeling and Drug Discovery Software – Assignments.

## Ph.D in HORTICULTURE( Floriculture and Landscape Architecture)

### *Compulsory courses*

Course No.	Titles	Credit hr.
FLA-601	Advances in breeding of flower crops	2+1
FLA-602	Advances in flower production technology - I	2+1
FLA-604	Advances in landscape architecture	1+2
FLA-606	Advances in flower production technology - II	2+1
FLA-607	INM in horticultural crops	2+1
FLA-691	Doctoral seminar – I	0+1
FLA-692	Doctoral seminar – II	0+1
FLA-699	Doctoral research	0+45

### *Optional courses*

Course No.	Titles	Credit hr.
FLA-603	Advances in protected and precision floriculture	1+1
FLA-605	Advances in biochemistry and biotechnology of flowers	2+1
FLA-608	Biotic and abiotic stress management in horticultural crops	2+1
FLA-609	Genomic and bioinformatics in horticultural crops	2+1

### **FLA-601: ADVANCES IN BREEDING OF FLOWER CROPS (2+1)**

#### **Theory**

UNIT I : Origin and evolution of varieties, distribution, Genetic resources, genetic divergence, Plant introduction, selection and domestication, Inheritance of important characters, Genetic mechanisms associated with flower colour and flower size, doubleness, fragrance and post-harvest life, Plant Variety Protection Act.

UNIT II : Specific objectives of breeding in flower crops, Methods of breeding suited to seed and vegetatively propagated flower crops, Introduction, selection, polyploidy and mutation breeding in the evolution of new varieties, Exploitation of heterosis, utilization of male sterility-Incompatibility problems, *in vitro* breeding.

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

UNIT IV: Specific breeding problems and achievements made in rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, gerbera, gladioli, orchids and anthurium.

UNIT V : Specific breeding problems and achievements made in aster, petunia, liliiums, heliconia, bird of paradise, hibiscus and bougainvillea.

#### **Practical**

Description of crops and cultivars; Cataloguing of species and cultivars, floral biology, selfing and crossing, evaluation of hybrid progenies; Induction of mutants; Physical and chemical mutagens; Induction of polyploidy; Screening of plants for biotic and abiotic stresses and environmental pollution; *in-vitro* breeding in flower crops.

## **FLA-602: ADVANCES IN FLOWER PRODUCTION TECHNOLOGY-I (2+1)**

### **Theory**

UNIT I : Commercial flower production; Scope and importance; Global Scenario in cut flower production and trade, varietal wealth and diversity; Soil and Environment; Special characteristics and requirements; cut flower and dry flowers.

UNIT II : Propagation and multiplication; IPR issues related to propagation of materials; Greenhouse management; Soil/media decontamination techniques; Microirrigation; nutrition and fertigation; slow release fertilizers and biofertilizers; influence of environmental parameters, light, temperature, moisture, humidity and CO<sub>2</sub> on growth and flowering; regulation for quality flowers.

UNIT III : Flower forcing and year-round flowering through physiological interventions; Chemical regulation; Environmental manipulation; Harvest indices; Harvesting techniques; Post-harvest handling; Precooling, pulsing, packing, marketing; Export potential; Agri Export Zones.

UNIT IV : Crop specific practices – rose, anthurium, orchids, carnation, gladioli, gerbera, liliams, heliconia, bird of paradise, tuberose, chrysanthemum, alstroemeria, alpinia.

UNIT V : Techniques of preserving flower, flower arrangement.

### **Practical**

Varietal wealth in flower crops; Greenhouse management; Soil decontamination techniques; Microirrigation; Nutrition and fertigation. Special practices- Pinching, netting, disbudding, defoliation and chemical pruning; Photoperiodic and chemical induction of flowering; Assessing harvest indices; Post-harvest handling; Tissue analysis; Preparation of dry flowers; flower arrangement, case studies; visit to commercial cut flower units.

## **FLA-603: ADVANCES IN PROTECTED AND PRECISION FLORICULTURE (1+1)**

### **Theory**

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

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

UNIT III : Water and nutrient management, crop regulation, special horticultural practices under protected cultivation of rose, chrysanthemum, carnation, orchids, anthurium, gerbera, liliams, cut foliage; Harvest indices – harvesting, PH handling, marketing, export.

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

UNIT V : Variability management in precision farming, mapping, variable rate technology, precision equipments, computers and robotics in precision farming, post-harvest process management in floriculture using precision

farming.

## **Practical**

Growing structures, basic considerations in establishment and operation of greenhouses, Environmental control systems in greenhouse, containers, substrate culture, soil decontamination techniques, Crop regulation, special horticultural practices under protected cultivation, precision equipments, computers and robotics in precision farming, post-harvest process management in floriculture using precision farming.

## **FLA-604: ADVANCES IN LANDSCAPE ARCHITECTURE (1+2)**

### **Theory**

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

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

UNIT III : Assessing site and plants adaptability for different locations, Landscape engineering (Topographical) survey and designing concept), special techniques in garden landscaping (Burlaping, waterscaping, hardscaping, lawn making, topiary styles specializing, bio aesthetic planning).

UNIT IV : Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing.

UNIT V : Contemporary landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Case study with the successful landscapist, Budget / Project cost estimating, Execution strategies, Assessing a successful design in site.

### **Practical**

Commercial landscaping, Plant identification, Materials of garden design, Design making by different garden styles and types. Way of designing a commercial landscape project, visit to model ornamental nursery. Assessing site and plants adaptability for different locations, Landscape engineering (Topographical survey and designing concept), special techniques in garden landscaping (Burlaping, waterscaping, hardscaping, lawn making, topiary styles specializing, bioaesthetic planning). Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing. Contemporary landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Case study with the successful landscapist, Budget/Project cost estimating, Execution.

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

### **Theory**

UNIT I : Biochemistry of flowers: Principle involved in the formation of pigments—chlorophyll, xanthophyll, carotenoids, flavonoids and anthocyanins. Chemistry and importance of secondary metabolites in rose, jasmine, marigold, tuberose, carnation, orchids, liliams and bougainvillea. Biochemistry and utilization commercial products (select items).

UNIT II : Recent trends- Extraction of biocolours and their value addition, uses in food and textile industries. Biochemistry of post harvest management of cut flowers.

UNIT III : Biotechnology – tools techniques and role in floriculture industry, physical factors and chemical factors influencing the growth and development of plant cell, tissue and organs, cytodifferentiation, organogenesis, somatic embryogenesis.

UNIT IV : *In vitro* lines for biotic and abiotic stress – Meristem culture for disease elimination, production of haploids through anther and pollen culture – embryo and ovule culture, micrografting, wide hybridization and embryo rescue techniques, construction of somatic hybrids and cybrids, regeneration and characterization of hybrids and cybrids, *in vitro* pollination and fertilization, hardening media, techniques and establishment of tissue culture plants in the primary and secondary nursery.

UNIT V : Somoclonal variation and its applications – variability induction through *in vitro* mutation, development of cell suspension cultures, types and techniques, *in vitro* production of secondary metabolites, role of bioreactors in production of secondary metabolites, quantification and quality analysis of secondary metabolites using HPLC, *in vitro* conservation and cryo-preservation techniques.

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

UNIT VII : Construction of c-DNA library, DNA fingerprinting technique in economic flower crop varieties, molecular approaches to control ethylene response, improving shelf life, improving resistance for environmental stress, approaches to improve flower development, pigment production, secondary metabolite production, post harvest biotechnology of flowers, ornamental plants, achievements of biotechnology in flower crops.

### **Practical**

Extraction of flower pigments – xanthophylls, carotenoids and anthocyanins. Plant nutrient stock- growth regulators- media preparation and sterilization- *In vitro* seed germination- callus culture and organ culture- Cell suspension culture – cell plating and regeneration- clonal propagation through Meristem culture, induction of multiple shoots- Anther- Pollen- Ovule and Embryo culture- Synthetic seed production, *in vitro* mutation induction, *in vitro* rooting – hardening at primary and secondary nurseries, Project preparation for establishment of low, medium and high cost tissue culture laboratories, DNA isolation from economic flower crop varieties – Quantification and amplification, DNA and Protein profiling – molecular markers for economic flower crops, restriction enzymes, vectors for cloning and particle bombardment, DNA fingerprinting of flower crop varieties.

## **FLA – 606 : ADVANCES IN FLOWER PRODUCTION TECHNOLOGY – II (2+1)**

### **Theory**

UNIT I : Scope and importance of loose flower, global scenario in loose flower production and trade, varietal wealth and diversity.



UNIT II : Soil and climate requirements, field preparation, systems of planting, precision farming techniques, propagation, sexual and asexual propagation methods, nursery management, transplanting techniques.

UNIT III : Advances in water, nutrient and weed management, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulator, IPM and IDM.

UNIT IV : Crop specific practices – *Jasminum* sp. marigold, crossandra, chrysanthemum, nerium, gomphrena, celosia, barleria, hibiscus, tuberose, scented rose, non-traditional flowers (nyctanthes, ixora, lilies, lotus, tecoma, tabernamontana).

UNIT V : Harvest indices, harvesting techniques, floral oil industry, floral concrete production, extraction methods.

### **Practical**

Botanical description of species and varieties, propagation techniques, special practices – pinching, disbudding, defoliation, training and pruning techniques, practices in manuring, foliar nutrition, growth regulator application, harvesting techniques, post harvest handling, essential oil extraction. Drying and preservation of loose flowers, visit to fields.

### **FLA-607 : INM IN HORTICULTURAL CROPS (2+1)**

#### **Theory**

Soil reaction and its relation with growth and cropping of different horticultural crops. Means to increase the nutrient use efficiency. Role of mycorrhiza in nutrition of horticultural crops. Fertilizer placement practices. Critical leaf nutrient content at different stages of growth, yield and nutrient content, removal of nutrients by crops. Micronutrients in horticultural crops- role and effect. Site specific nutrient management. Integrated nutrient management. Influence of rootstock in nutrients uptake.

#### **Practical**

Studies on the deficiency symptoms of major fruits, vegetables and plantation crops. Nutrition study by sand culture techniques. Estimation of major and micronutrients of leaf and shoot. Leaf nutrient standards using DRIS norms. Yield forecasting following the leaf nutrient standards. Use of isotopes for study of nutrient mobility in the plant.

### **FLA-608: BIOTIC AND ABIOTIC STRESS MANAGEMENT IN HORTICULTURAL CROPS (2+1)**

#### **Theory**

UNIT I : Environmental stress and its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress; root stock, use of wild species, use of anti transpirants.

UNIT II : Mechanism and measurements of tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

UNIT III : Soil-plant-water relations under different stress conditions in vegetable crops production and their management practices.

UNIT IV : Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

UNIT V : Techniques of vegetable growing under high and low temperature conditions, use of chemicals in alleviation of different stresses.

### **Practical**

Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops, measurement of tolerance to various stresses in vegetable crops, short term experiments on growing vegetable under water deficit, water-logging, salinity and sodicity, high and low temperature conditions, and use of chemicals for alleviation of different stresses.

## **FLA-609: GENOMICS AND BIOINFORMATICS IN HORTICULTURAL CROPS (2+1)**

### **Theory**

UNIT I : Primer on bioinformatics and computational genomics, database fundamentals – biological databases, horticultural genome and protein databases, functional genomics.

UNIT II : Dynamic Programming Sequence Alignment, BLAST search engine, FASTA search engine, Microarrays- Microarray Clustering and Classification, Terminologies and Ontologies - EcoCYC knowledge base of E. Coli metabolism - Description of UMLS Semantic Network.

UNIT III : Multiple Sequence Alignment, MSA algorithm descriptions, ClustalW, 1D Motifs, Algorithms and Databases, methods for sequence weighting, BLOCKS database, Making BLOCK motifs, PROSITE database, 3D structure alignment, SCOP, DALI, LOCK, MUSTA algorithm for geometric hashing and multiple alignment.

UNIT IV : Hidden Markov models , Molecular energetics and dynamics , Protein structure prediction, Genetic networks - Modeling and Simulation of Genetic Regulatory Systems- KEGG database of genes and gene pathways/networks - EcoCYC database of metabolic pathways in E. Coli - EGF-signal pathway modeling, Gene finding algorithms – Genome Annotation Assessment Project for Arabidopsis, Comparative genomics algorithms, Genome Alignment.

UNIT V : 3Dstructure computations, NMR, Xtallography, NMR Structure Determination, X-ray Crystallography Structure Determination, Distance Geometry Description, RNA secondary structure, Molecular Modeling and Drug discovery programs.

UNIT VI : Phylogenetic algorithms - Treebase database of phylogenetic information for plants mostly, Tree of Life Page, Samples from the Tree of Life, Ribosomal Database Project, Natural Language Processing , Proteomics, 3D Motifs, Applications and Integration with Horticulture, Final Thoughts.

### **Practical**

Computers, Operating systems and Programming languages, Internet Resources, Horticultural Genome and Protein Databases, BLAST/RNA Structure, Sequence Alignment, Microarray Data Analysis, Ontology, MSA, HMMs, Identification of Functional Sites in Structures, Protein Structure Prediction - Phylogenetics - Gene Finding - Molecular Modeling and Drug Discovery Software – Assignments.

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## Ph.D in HORTICULTURE( Plantation, Spices, Medicinal and Aromatic Crops)

### *Compulsory courses*

Course No.	Titles	Credit hr.
PSMA-601	Advances in production of plantation crops	2+1
PSMA-602	Advances in spice production	2+1
PSMA-603	Advances in medicinal and aromatic crop production technology	2+1
PSMA-604	Advances in breeding of plantation crops and spices	2+1
PSMA 691	Doctoral seminar I	1+0
PSMA 692	Doctoral seminar II	1+0
PSMA 699	Doctoral research	45

### *Optional courses*

Course No.	Titles	Credit hr.
PSMA-605	Advances in breeding of medicinal and aromatic crops	2+1
PSMA-606	Biotechnology in plantation crops and spices	1+1
PSMA-607	Post harvest processing and extraction in medicinal and aromatic crops	2+1
PSMA-608	Environmental horticulture	2+1

### **PSMA-601: ADVANCES IN PRODUCTION OF PLANTATION CROPS (2+1)**

#### **Theory**

Plantation crops – area and production, export potential - varietal wealth and appraisal on the crop improvement in plantation crops. Mass multiplication techniques, High density planting, systems of cultivation, multitier cropping, companion cropping, studies of on canopy and root management, photosynthetic efficiencies of crops at different tiers, Biotic and abiotic factors on growth and productivity, nutritional requirements, role of macro and micro nutrients, Nutrient deficiency symptoms, growth regulators, water requirement, fertigation, soil and moisture conservation practices, Drought management, permanent vegetation management, Basin management, training and pruning, maturity indices, harvesting, curing, processing and value addition, grading, packing and storage, role of commodity boards in plantation crop development, Production of plantation crops through GAP, GMP, HACCP.

#### **Crops**

UNIT I: Coffee and tea

UNIT II: Cashew and cocoa

UNIT III: Rubber, palmyrah and oil palm

UNIT IV: Coconut and arecanut

UNIT V: Wattle and betelvine

#### **Practical**

Description of botanical and varietal features-selection of mother palms and elite clones, Clonal fidelity testing, nursery techniques and propagation methods, High density planting, training and

pruning practices, fertigation and foliar nutrition, shade regulation, maturity standards, harvesting, curing, processing and grading, project preparation for establishing new plantations, visit to plantation gardens, commodity boards and plantation based industries.

### **PSMA-602: ADVANCES IN SPICE PRODUCTION (2+1)**

#### **Theory**

Spices- current status on area and production, state, national and global scenario of spices, global trade, problems encountered in spices productivity, systems of cultivation, varieties, soil and climate, propagation techniques and nursery management, planting systems and methods, cropping pattern, permanent floor management concepts in mulching and weed management, canopy and root studies under different spice-based cropping systems, shade and basin management, INM practices, irrigation and fertigation techniques, chemical regulation of crop productivity, IPM, clean cultivation strategies, harvesting, Post-harvest and quality management for value added spices, quality standards, GAP and GMP for spices production, quality control and certification. Protected cultivation of high value spice crops. Value addition and byproduct utilization. Precision farming and organic farming in spice crops. Commodity Boards in spices development

UNIT I: Pepper and cardamom

UNIT II: Nutmeg, clove, cinnamon and allspice

UNIT III: Turmeric, ginger, garcinia, tamarind and garlic

UNIT IV: Coriander, fenugreek, fennel, cumin and vanilla

UNIT V: Paprika and important herbal spices

### **PSMA-603: ADVANCES IN MEDICINAL AND AROMATIC CROP PRODUCTION TECHNOLOGY (2+1)**

#### **Theory**

##### UNIT I

Genetic biodiversity of medicinal plants, Conservation networks, Global initiatives on medicinal plants conservation and development, World history on usage of medicinal plants, Preference to natural products, Advanced research in biomedicines, Nutraceuticals and natural drugs, American, European and Asian legislations on plant drugs, Intellectual Property Rights, Patents.

##### UNIT II

Indian traditional wisdom and Heritage- Indian herbal wealth, Documentations, Databases, Scientific validation, Production Problems of Medicinal and Aromatic plants, Export and import status. WTO scenario - Principles and guidelines for GAP, GCP and GMP in medicinal crops.

##### UNIT III

Climate, Soil and substrate culture, Improved varieties, Organic production, Nutrition and irrigation requirements, inter culture, mulching, Weed control, Maturity indices and Harvesting, Post-harvest handling, Drying, Processing, Grading, Packing and Storage, Quality standards in medicinal plants, Biotechnological approaches for advances in phytochemical extraction technologies, Separation of Bio-molecules, Distillation methods, Essential oil extraction and value addition in aromatic plants, Phytochemicals and drug development.

##### UNIT IV

Medicinal crops : *Coleus forskohlii*, Glory lily, Senna, Periwinkle, *Stevia rebaudiana*, Aswagandha, Sarpagandha, *Aloe vera*, *Dioscorea* sp, *Phyllanthus amarus*, *Andrographis*

*paniculata*, Medicinal solanum, Isabgol, *Poppy*, *Digitalis* sp, *Commiphora* sp, *Ipecac*, *Henbane*, *Ocimum* sp., *Centella*, *Bacopa*, *Saraca indica* and *Bael*.

#### UNIT V

Aromatic crops: Palmarosa, Lemongrass, citronella, vetiver, Geranium, Artemisia, Mentha, Ocimum, Eucalyptus, Rosemary, Thyme, patchouli.

#### **Practical**

Identification and documentation- propagation in medicinal crops, Maturity standards, Harvesting and Drying techniques, Processing and grading, Analysis of bio-molecules, Extraction of secondary metabolites, identification and characterization of - secondary metabolites, Essential oils, Visit to commercial medicinal plants field, Visit to GMP phytochemical extraction and value addition unit.

### **PSMA-604: ADVANCES IN BREEDING OF PLANTATION CROPS AND SPICES**

(2+1)

#### **Theory**

Evolutionary mechanisms, adaptation and domestication, genetic resources, genetic divergence, cytogenetics, variations and natural selection, types of pollination and fertilization mechanisms, sterility and incompatibility system, recent advances in crop improvement efforts, introduction and selection, chimeras, clonal selections, intergeneric, interspecific and intervarietal hybridization, heterosis breeding, mutation and polyploidy breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, genetics of important traits and their inheritance pattern, molecular and transgenic approaches and other biotechnological tools in improvement of selected spice and plantation crops.

#### **Crops**

UNIT I: Coffee and tea

UNIT II: Cashew and cocoa

UNIT III: Rubber, palmyrah and oil palm

UNIT IV: Coconut and arecanut

UNIT V: Pepper and cardamom

UNIT VI: Nutmeg, clove, cinnamon and allspice

UNIT VII: Turmeric, ginger, garcinia, tamarind and garlic

UNIT VIII: Coriander, fenugreek, fennel, cumin and vanilla

#### **Practical**

Description and cataloguing of germplasm, pollen viability tests, pollen germination, survey and clonal selection, screening techniques for abiotic stresses, screening and rating for pest, disease and stress resistance in inbreds and hybrids, estimation of quality and processing characters for quality improvement, use of mutagens and colchicine for inducing mutation and ploidy changes, practices in different methods of breeding and *in vitro* breeding techniques.

### **PSMA-605: ADVANCES IN BREEDING OF MEDICINAL AND AROMATIC CROPS**

(2+1)

#### **Theory**

UNIT I : Origin and evolution of varieties, distribution- Genetic resources, genetic divergence, Plant introduction, selection and domestication - Inheritance of important characters, Genetic mechanisms associated with alkaloids and secondary metabolites.

UNIT II : Methods of breeding suited to seed and vegetative propagated crops. Polyploidy and mutation breeding in the evolution of new varieties, Exploitation of heterosis, utilization of male sterility. Breeding for resistance to pests, diseases, nematodes in medicinal and aromatic crops.

UNIT III : Specific breeding objectives in medicinal and aromatic crops, Genetic biodiversity, Breeding problems and improvements in Senna, Periwinkle, Aswagandha, Isabgol, Sarpagandha, Poppy, Glory lily, *Coleus*, *Mucuna* and *Ocimum*, Centella, Bacopa, Dioscorea, Solanum, Andrographis, *Aloe vera*, Phyllanthus, Eucalyptus, Bael, Cinchona.

UNIT IV : Specific breeding objectives in medicinal and aromatic crops, Genetic bio diversity, Breeding problems and improvements in Henbane aromatic grasses, Geranium, Patchouli, Artemisia, Rosemary, Thyme, Sage, Marjoram, Fever few.

UNIT V : Biotechnological approaches for crop improvement of medicinal and aromatic crops.

### **Practical**

Description of crops and cultivars, Cataloguing of species and cultivars, floral biology, selfing and crossing, evaluation of hybrid progenies, Induction of economic, colour mutants, Increased alkaloid content in medicinal crops, high essential oil content in aromatic plants, Physical and chemical mutagens, Induction of polyploidy, Screening of plants for biotic and abiotic stresses and environmental pollution, *in-vitro* breeding in flower crops, medicinal and aromatic crops.

## **PSMA-606: BIOTECHNOLOGY IN PLANTATION CROPS AND SPICES (1+1)**

### **Theory**

**Crops:** Coconut, oil palm, coffee, tea, cocoa, pepper, cardamom, turmeric, ginger, vanilla

UNIT I : *In vitro* culture methods and molecular approaches for crop improvement in plantation crops and spices, production of haploids, disease elimination in horticultural crops, micro grafting; somoclonal and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, *in vitro* production of secondary metabolites.

UNIT II : Protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in vitro* conservation of spices and plantation crops.

UNIT III : *In vitro* mutation for biotic and abiotic stresses, recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology.

UNIT IV : Quality improvement; improvement for biotic and abiotic stresses; transgenic plants.

UNIT V : Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements, problems and future thrusts in horticultural biotechnology.

### **Practical**

Establishment of axenic explants, callus initiation and multiplication; production of suspension culture, cell and protoplast culture, fusion, regeneration and identification of somatic hybrids and cybrids, Identification of embryonic and non-embryonic calli, development of cell lines; *in vitro* mutant selection for biotic and abiotic stresses, *In vitro* production and characterization of secondary metabolites, isolated microspore culture, isolation and amplification of DNA, gene transfer methods; molecular characterization of transgenic plants.

## **PSMA-607: POST-HARVEST PROCESSING AND EXTRACTION IN MEDICINAL AND AROMATIC PLANTS (2+1)**

### **Theory**

UNIT I : Post-harvest handling of plant material, preparation of plant material for packaging and extraction. Methods of extraction of secondary metabolites from medicinal crops like sarpagandha, steroid-bearing solanums, ashwagandha, henbane, periwinkle, senna, costus, coleus, etc.

UNIT II : Procedures and equipments used for extraction of active principles. Principles and practices of different types of chromatographs - paper, thinlayer, column, gas and high performance liquid chromatography and massspectroscopy. Preservation of plant extracts and their trade mechanisms.

UNIT III : Harvesting, drying, handling and preparation of different aromatic crops - jasmine, tuberose, oil-bearing rose, scented geranium, patchouli, davana, mints, basils, etc., for essential oil extraction.

UNIT IV : Principles and practices of different types of extraction - distillation, solvent extraction, supercritical fluid extraction, etc. Fine flavour and perfume extraction. Qualitative determination of essential oils. *In vitro* production of biomass and organic extraction of oils. Quality analysis and characterization through chromatographs.

UNIT V : Commercial uses of essential oils, aromatherapy, etc. Commercial utilization of spent material. Storage of essential oils.

### **Practical**

Identification of different economic parts of medicinal and aromatic crops. Preparation of plant material for extraction. Study of different extraction methods. Study of solvents used in extraction of concrete and absolutes. Extraction of crude drugs and essential oils from different medicinal and aromatic crops respectively. Handling of different chromatographs. Quality analysis of essential oils - both physical and chemical, determination of phenol values, acid values, alcohol values, etc. Sensory evaluation of essential oils. Storage studies in essential oils. Visit to commercial extraction and product development units.

## **PSMA-608 : ENVIRONMENTAL HORTICULTURE (2+1)**

### **Theory**

UNIT I : Environmental complex, interaction of ecological factors in horticultural crop production, interaction of physiographic factors in horticultural crop production. Geo-chemical and hydrological cycles and their impact on ecosystems.

UNIT II : Global warming- carbon trading role of green house gases, elevated CO<sub>2</sub> and its impact on productivity of horticultural systems. Habitat ecology, changes in habitats and its impact on horticultural production, Habitat analysis, conservation biology, domestication. Forest ecosystem and its evolution to a hort-ecosystem.

UNIT III : Phytogeography. changes in land use pattern and its impact on horticultural crop production. Natural resource management in horti systems. Subsistence farming systems of the world threat and challenges.

UNIT IV : Environmental pollution in horti systems, chemicals, fertilizers, etc. Waste management in processing industry, phytoremediation. Alternate farming systems, horticultural therapy Environmental policy & legislation in India, International treaties and Summit, Biodiversity Board, Act, etc.

### **Practical**

Phyto-sociological analysis, assessment of plant associations in natural and domestic systems, productivity assessment of various ecosystems, analysis and assessment of various



phytogeographic zones, assessment of land use changes and its impact on horticultural systems, assessment of biodiversity, pesticide residue analysis in horticultural produce.