

SCHOOL OF AGRICULTURE

Ph.D. IN HORTICULTURE

Courses Offered:

- 1. VEGETABLE SCIENCE / OLERICULTURE**
- 2. FRUIT SCIENCE/POMOLOGY**
- 3. FLORICULTURE & LANDSCAPING / FLORICULTURE &
LANDSCAPE ARCHITECTURE**

1. Production Technology of Cool Season Vegetable Crops

Introduction, climatic and soil requirement, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting of potato, chow chow, cole crops: cabbage, cauliflower, knolkhol, sprouting broccoli, Brussels sprout, root crops: carrot, radish, turnip, and beetroot, bulb crops: onion and garlic, Peas and beans, leafy vegetables: palak

2. Production Technology of Warm Season Vegetable Crops

Introduction, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting of: Tomato, eggplant, hot and sweet pepper, Okra, vegetable cowpea, Dolichos lablab and cluster bean, Cucurbitaceous crops, and sweet potato, cassava, yams, coclocasia, moringa and amaranths.

3. Breeding of Vegetable Crops

Cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, biotechnology and their use in breeding in vegetable crops - molecular marker, genomics, marker assisted selection and QTLs. Potato and tomato, Eggplant, hot pepper, sweet pepper and okra, Peas and beans, lettuce, gourds, melons, pumpkins and squashes, cabbage, cauliflower, carrot, beetroot, radish, moringa, amaranthus, cassava, sweetpotato, lab lab, onion and garlic

4. Growth and Development

Cellular structures and their functions; definition of growth and development, growth analysis and its importance in vegetable production; Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellins, cytokinins and abscisic acid; Application of synthetic hormones, plant growth retardants and inhibitors for various purposes in vegetable crops; sex expression in cucurbits and checking flower and fruit drops and improving fruit set in Solanaceous vegetables Role and mode of action of antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production; Role of light, temperature and photoperiod on growth, development of underground parts, apical dominance; Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening; Plant growth regulators in relation to morphogenesis and tissue culture techniques in vegetable crops.

5. Seed Production

Introduction, importance and present status of vegetable industry.; modes of propagation in vegetables; Seed morphology and development in vegetable seeds; Floral biology of these plant species; classification of vegetable crops based on seed dormancy/pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops; methods of seed production; comparison between different methods e.g. pollination mechanisms; sex types, ratios and expression and modification of flowering pattern in cucurbits; nursery raising and transplanting stage; Seed production technology of vegetables viz. solanaceous, cucurbitaceous, leguminous, malvaceae, cole crops, leafy vegetables, root, tuber and bulb crops; harvesting/picking stage and seed extraction in fruit vegetables, grading, storage, seed quality testing and seed certification standards; clonal propagation and multiplication in tuber crops e.g. Potato and sweet potato, seed-plot technique in potato, TPS (True Potato Seed); hybrid seed production technology of vegetable crops; maintenance of parental lines; use of male sterility and self-incompatibility in hybrid seed production.

6. Systematics of Vegetable Crops

Principles of classification; different methods of classification; salient features of international code of nomenclature of vegetable crops; Origin, history, evolution and distribution of vegetable crops, taxonomy, botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables; Floral biology, Cytological level of various vegetable crops; descriptive keys for important vegetables; Importance of molecular markers in evolution of vegetable crops; molecular markers as an aid in characterization and taxonomy of vegetable crops :Potato and tomato, Eggplant, hot pepper, sweet pepper and okra, Peas and beans, lettuce, gourds, melons, pumpkins and squashes, cabbage, cauliflower, carrot, beetroot, radish, moringa, amaranthus, cassava, sweetpotato, lab lab, onion and garlic

7. Production Technology of Underexploited Vegetable Crops

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, planting time and method, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting of: Asparagus and leek; Chinese cabbage, Chinese potato, and kale; Amaranth, , parsnip, rhubarb, basella and bathu (chenopods); lima bean, winged bean, vegetable pigeon pea and sword bean; Sweet gourd, spine gourd, pointed gourd, Ivy gourd

8. Post-Harvest Technology of Vegetable Crops

Importance and scope of post-harvest management of vegetables; Maturity indices and standards for different vegetables; methods of maturity determinations; biochemistry of maturity and ripening, enzymatic and textural changes, ethylene evolution and ethylene management,

respiration, transpiration, regulation methods; Harvesting tools, harvesting practices for specific market requirements; grading, post-harvest physiological and biochemical changes, disorders-chilling injury in vegetables, influence of pre-harvest practices and other factors affecting post-harvest losses, packaging house operations, commodity pre-treatments- chemicals, wax coating, pre-packaging and irradiation; packaging of vegetables, post-harvest, diseases and prevention from infestation, principles of transport; Methods and practices of storage-ventilated, refrigerated, MA, CA storage, hypobaric storage, precooling and cold storage, zero energy cool chamber; HACCP, Codex, FSSAI.

9. Organic Vegetable Production Technology

Importance, principles, prospective, concept and component of organic production of vegetable crops, managing soil fertility, pest, disease and weed problem in organic farming system, crop rotation in organic vegetable production. Method of enhancing soil fertility, mulching, raising green manure crops, indigenous methods of compost, panchgavya, biodynamics preparation, ITKs organic farming. Role of botanicals and bio-control agents. GAP and GMP, organic certification standards, opportunity and challenges in organic production of vegetables.

10. Hi-tech Production Technology of Vegetable Crops

Importance and scope of protected cultivation of vegetable crops, principles used in protected cultivation and greenhouse technology, effect of temperature, carbon dioxide, humidity; energy management, low cost structures, training methods, engineering aspects, classification of protected structures including low cost poly-house/green houses and other structures in vegetable production, types of cladding material, types of media, Mulching, solarisation, fumigation, Drip and sprinkler irrigation, fertigation, special horticultural practices, hydroponics, vertical farming and soilless culture for enhancing productivity and off-season of high value vegetable crops like tomato, capsicum and cucumber.

1. Tropical and Dry Land Fruit Production

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, scion-stock relationship, planting systems, cropping systems, canopy management, nutrient management, water management, fertigation, role of bio-regulators, abiotic factors limiting fruit production, physiology of flowering, pollination, fruit set and development, honeybees in cross pollination, physiological disorders—causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones (AEZ) and industrial supports. Crops: Mango, Banana, Citrus, Papaya, Guava, Sapota, Annonas, Aonla, Bael, Wood apple, Jamun, Pomegranate, Ber and minor fruits of tropics.

2. Subtropical and Temperate Fruit Production

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, scion-stock relationship, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bio - regulators, abiotic factors limiting fruit production, physiology of flowering, pollination, fruit set and development, honeybees in cross pollination, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones (AEZ) and industrial supports. Crops: Avocado, Pineapple, Jackfruit, Mangosteen, Carambola, Fig and Rambutan, Litchi, Loquat, Apple, Pear, Quince, Grapes, Plums, Peach, Apricot, Cherries, Persimmon, Kiwifruit, Strawberry, Walnut, Almond, Pistachio, Hazelnut.

3. Biodiversity and Conservation

Biodiversity and conservation; issues and goals, centres of origin of cultivated fruits; primary and secondary centres of genetic diversity; present status of gene centres; exploration and collection of germplasm; Role of NAGS ; Conservation of genetic resources—conservation *insitu* and *exsitu*. Germplasm conservation – problem of recalcitrancy-cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine; intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group; GIS and documentation of local biodiversity, geographical indication. Crops: Mango, Sapota, Citrus, Guava, Banana, Papaya, Grapes, Jackfruit, Custard apple, Ber, Aonla, Malus & Prunus sp., Litchi and Nuts.

4. Canopy Management in Fruit Crops

Canopy management - importance and advantages; factors affecting canopy development;

Canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies; Spacing and utilization of land area - canopy classification; Canopy management through rootstock and scion; Canopy management through plant growth retardants, training and pruning and management practices; Canopy development and management in relation to growth, flowering, fruiting and fruit quality in temperate fruits, Grapes, Mango, Sapota, Guava, Citrus and Ber.

5. Breeding of Fruit Crops

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, breeding constraints, ideotypes, approaches for crop improvement – introduction, selection, hybridization, mutation breeding, polyploidy breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops. Crops: Mango, Banana, Pineapple, Citrus, Grapes, Guava, Sapota, Jackfruit, Papaya, Custard apple, Aonla, Avocado, Ber, Litchi, Jamun, Phalsa, Mulberry, Raspberry, Apple, Pear, Plums, Peach, Apricot, Cherries and Strawberry.

6. Post-Harvest Technology

Maturity indices, harvesting practices and grading for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration; Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling; Treatment prior to shipment, *viz.*, chlorination, waxing, chemicals, bio-control agents and natural plant products, fungicides, hot water, vapour heat treatment, sulphur fumigation and irradiation. Methods of storage-ventilated, refrigerated, MAS, CA storage, physical injuries and disorders; Packing methods and transport, quality evaluation, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jelly, candy; Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management and food safety standards; Role of HACCP.

7. Growth and Development

Definition, parameters of growth and development, growth dynamics, morphogenesis; Annual, semi-perennial and perennial horticultural crops, environmental impact on growth and development, effect of light, photosynthesis and photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism; Assimilate partitioning during growth and development, influence of water and mineral nutrition during growth and development, biosynthesis of auxins, gibberellins, cytokinins, abscisic acid, ethylene, brassinosteroids, growth inhibitors, morphactins, role of plant growth promoters and inhibitors, developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase,

flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development; Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth development.

8. Biotechnology of Fruit Crops

Harnessing bio-technology for improvement of 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 and cells, regeneration of tissues, *ex vitro*, establishment of tissue culture plants; Physiology of hardening - hardening and field transfer, organ culture-meristem, embryo, anther, ovule culture, embryo rescue, soma clonal 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 and transformation in horticulture crops, use of molecular markers. *In vitro* selection for biotic and abiotic stress, achievements of biotechnology in horticultural crops and application of gene editing tools in horticultural crops.

9. Protected Fruit Culture

Greenhouse – world scenario, Indian situation; present and future, different agro-climatic zones in India, environmental factors and their effects on plant growth; Basics of green house design, different types of structures-glasshouse, shade net, poly tunnels-Design and development of low cost green house structures; Interaction of light, temperature, humidity, CO₂, water on crop regulation - Greenhouse heating, cooling, ventilation and shading; Types of ventilation-Forced cooling techniques-Glazing materials-Micro irrigation and Fertigation; Automated green houses, microcontrollers, waste water recycling, management of pest and diseases-IPDM.

10. Principles and Practices of Plant Propagation

Introduction, life cycle in plants, cellular basis for propagation. Sexual propagation – apomixis, polyembryony, chimeras. Factors influencing seed germination, hormonal regulation of germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing. Rooting of cuttings under mist and hot beds. Physiological, anatomical and biochemical aspects of root induction in cuttings. Selection of elite mother plants. Establishment of bud wood bank. Stock, scion and inter stock relationship and incompatibility. Physiology of dwarfing rootstocks. Rejuvenation of senile and seedling orchards progeny orchard and scion bank. Micropropagation *In vitro* clonal propagation, director ganogenesis, embryogenesis, micro grafting and meristem culture. Hardening, packing and transport of micro-propagules.

3. FLORICULTURE & LANDSCAPING / FLORICULTURE & LANDSCAPE ARCHITECTURE

1. Breeding

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

2. Production Technology of Cut Flowers

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 CO₂ on growth and flowering; Flower production – water and nutrient management, rationing, fertigation, weed management, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes; 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 and transportation, marketing, export potential, institutional support, Agrl. Export Zones; Crops: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, lilies, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliage.

3. Production Technology for Loose Flowers

Scope of loose flower trade, Significance in the domestic /export markets, Varietal wealth and diversity, propagation, sexual and asexual propagation methods, propagation in mist chambers, nursery management, pro-tray nursery under shadenets, transplanting techniques; Soil and climate requirements, field preparation, systems of planting, precision farming techniques; Water and nutrient management, weed management, 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, Agrl. Export Zones; Crops – Jasmine, scented rose, chrysanthemum, marigold, tuberose, crossandra, nerium, hibiscus, celosia, gomphrena, non-traditional flowers (barleria, Nyctanthes, Tabernaemontana, ixora, lotus, pandanus, etc.).

4. Landscaping

Landscape designs, Styles of garden, formal, informal and free style gardens, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, Vanas, Buddha garden; Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporates; Garden plant components, arboretum, 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, colour wheels, temple garden, sacred groves; Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

5. Protected Floriculture

Prospects of protected floriculture in India; Types of protected structures – Greenhouses, polyhouses, shade houses, rain shelters etc., Designing and erection of protected structures; Low cost/Medium cost/High cost structures – economics of cultivation; Location specific designs; Structural components; Suitable flower crops for protected cultivation; Environment control – management and manipulation of temperature, light, humidity, air and CO₂; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation; 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, Pre-cooling, sorting, grading, packing, storage, quality standards.

6. Value Addition

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 loose flowers, garlands, veni, floats, floral decorations, value addition in cut flowers, flower arrangement styles, Ikebana, moribana, 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, button holes, greeting cards, wreaths; Packing and storage; Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Plant pigments: Significance of natural pigments, Applications; Selection of species and varieties, Types of pigments - carotenoids, anthocyanin, chlorophyll, betalains; Extraction methods; Packing and storage, .

7. Turfing and Turf Management

Prospects of landscape industry, History of landscape gardening, site selection, basic 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 playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, etc.

8. Computer Aided Designing (CAD) for Outdoor and Indoorscaping

Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHICAD, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing; 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LOT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects; Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking, Script making, Using productivity tools, e-transmit file, making sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout; 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.