

SYLLABUS: DEPARTMENT OF HORTICULTURE

Courses offered by Department of Horticulture in M. Sc. (Ag.) programme

Course No	Course Title	Credit	Semester
HOR 501*	Growth and development of fruit, vegetable and ornamental crops	2+1	I
HOR 502*	Fundamentals of fruit, vegetable and ornamental crops	2+1	I
HOR 503*	Basics of plantation, spices, medicinal & aromatic crops	2+0	II
HOR 504*	Post harvest technology of fruit, vegetable and ornamental crops	2+1	III
HOR 505*	Technological advancement of fruit, vegetable and ornamental crops	2+0	III
Major in Fruit Science			
HOR 511 [§]	Propagation and nursery management in horticultural crops	1+1	I
HOR 512 [§]	Tropical and dry land fruit production	2+1	I
HOR 513 [§]	Subtropical and temperate fruit production	2+1	II
HOR 514 [§]	Breeding of fruit crops	1+1	II
HOR 515	Biodiversity and conservation of fruit crops	1+1	II
HOR 516	Canopy management in fruit crops	1+1	III
HOR 517	Biotechnology of horticultural crops	2+1	II
HOR 518	Organic horticulture	1+1	III
Major in Vegetable Science			
HOR 521 [#]	Production technology of cool season vegetable crops	2+1	II
HOR 522 [#]	Production technology of warm season vegetable crops	2+1	I
HOR 523 [#]	Breeding of vegetable crops	2+1	II
HOR 524 [#]	Seed production technology of vegetable crops	2+1	III
HOR 525	Systematics of vegetable crops	1+1	I
HOR 526	Production technology of underexploited vegetable crops	1+1	II
HOR 527	Organic vegetable production technology	1+1	III
HOR 528	Fundamentals of processing of vegetables	1+1	III

development of underground parts, flowering and sex expression in horticultural crops; influence of water and mineral nutrition during growth and development; apical dominance.

UNIT IV & V

Auxins, gibberellins, cytokinins and abscissic acid; biosynthesis of auxins, gibberellins, cytokinins, abscissic acid, ethylene; role and mode of action of brassinosteroids, growth inhibitors, morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants; Application of synthetic hormones, plant growth retardants and inhibitors for various purposes in horticultural crops.

UNIT VI & VII

Physiology and bio-chemistry of seed germination. Dormancy: physiology, causes, method of breaking etc.; bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, flower and fruit drop, fruit growth, ripening and seed development; parthenocarpy.

UNIT VIII

Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth development.

Practical

Techniques of growth analysis; evaluation of photosynthetic efficiency; study of growth regulator, Preparation of solutions of plant growth substances and their application; understanding ripening phenomenon in fruits and vegetables; understanding stress impact on growth and development.

Learning Outcome:

Students will acquire theoretical and practical knowledge on physiology of horticultural crops, PGR and their functions uses and biotic and abiotic stresses.

HOR 502 Fundamentals of fruit, vegetable and ornamental crops

2+1

Objectives:

The students are expected to gain the fundamental knowledge on importance, branches and area specific different types of horticultural crops and their classification, techniques of orchard and garden establishment.

Syllabus:

Theory

UNIT I

Importance of horticulture in nutritional security and national economy; Horticultural geography (regions and zones); Present status and prospects of important horticultural crops.

UNIT II

Classification of fruit crops; Propagation technique; nursery management; training and pruning; rootstock and scion; causes of unfruitfulness and control; Orchard establishment and orchard floor management.

UNIT III

Classification of vegetable crops; types of vegetable farming; factors affecting vegetable productivity; economics, marketing and export potential of vegetable crops etc.

UNIT IV

Importance of flower crops and ornamental plants. Global Scenario of flower production and trade; classification of ornamental plants; Landscape designs, Bioaesthetic planning; types and styles of gardens; landscaping; Garden plant components; brief ideas about lawn, indoor gardening, pot culture, bonsai, hanging baskets, avenue trees, water garden, rockgardens, herbaceous and shrubbery borders, hedges and edging plants etc.

Practical

Identification of various horticultural crops, garden plants, garden implements etc.; preparation of layout and schemes for gardens; preparation of rooting media; potting and repotting; propagation techniques of horticultural crops; preparation of seed bed/nursery bed for vegetables and annuals; economic analysis; visit to commercial flower growing areas, nurseries etc.

Learning Outcome:

Students will acquire theoretical and practical knowledge on horticultural crops and their classification, establishment of orchard, vegetables cultivation and landscaping

Objectives:

The students are expected to gain the basic knowledge on importance and propagation techniques, varieties and cultivation practices and processing techniques of different types of plantation, spices, medicinal and aromatic crops.

Syllabus:**Theory**

UNIT I

Importance of plantation crops grown in India. Role of plantation crops in national economy and export potential.

UNIT II & III

Plant multiplication, systems of cultivation, rainfall, humidity, temperature, light and soil pH on crop growth and productivity, nutritional and water requirements, shade regulation, weed management, training and pruning, crop regulation, maturity indices, harvesting and processing of produce of: Coffee, Tea, Cashew and Coconut.

UNIT IV

Introduction; importance of spice crops; historical accent, present status (national and international), future prospects and export potential of spice crops; organic spices.

UNIT V & VI

Climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed / planting material, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, harvesting, post harvest management, plant protection measures of: Black pepper, cardamom, turmeric, ginger and garlic, Coriander and fenugreek.

UNIT VII

Herbal industry, WTO scenario, Export and import status, Indian system of medicine, Indigenous Traditional Knowledge, Classification of medicinal crops.

UNIT VIII & IX

Production technology, post harvest handling (drying, processing, grading, packing and storage), processing and value addition and quality standards in herbal products for Senna, Periwinkle, Aswagandha, Sarpagandha, *Dioscorea* sp., *Aloe vera*, medicinal solanum, Isabgol, Poppy and *Ocimum* sp.

UNIT X

Aromatic industry, WTO scenario, Export and import status, Indian perfumery industry, History, Advancements in perfume industry.

UNIT XI

Production technology, post-harvest handling, distillation methods, value addition, aroma chemicals, quality standards and regulations for palmarosa, lemongrass, citronella, vetiver, geranium, mentha, ocimum, eucalyptus, patchouli and lavender.

Learning Outcome:

Students will acquire theoretical and practical knowledge on of different types of plantation, spices, medicinal and aromatic crops, their processing and use.

HOR 504 Post harvest technologies of fruit, vegetable and ornamental crops 2+1

Objectives:

The students will gain the knowledge on pre and post-harvest physiology and management technologies of fruits and vegetables. Students are also expected to gain knowledge on conventional and modern packaging and preservation technology of fruits, vegetables and ornamental crops.

Syllabus:

Theory

UNIT I & II,

History and importance of post harvest technology; Composition and nutritive value of horticultural crops. Factors leading to post-harvest loss. Maturity indices of horticultural crops. Harvesting practices for specific market requirements, Pre-harvest crop management practices and their influence on quality during storage and marketing. Respiration, transpiration. Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management.

UNIT III

Post harvest handling (harvesting, sorting, grading and packing and transportation) of fruits, vegetables and flowers. Post harvest treatments (pre cooling, hot water, hot air and vapour heat, fungicide & biologically safe chemicals, irradiation, curing, pulsing etc.) for quality retention of horticultural crops.

UNIT IV

Storage systems - on farm storage (evaporative cooled stores, ventilated storage, pit storage etc.), refrigerated storage, controlled / modified atmosphere storage, hypobaric, hyperbaric storage. Physical injuries and disorders.

UNIT V

Contamination and spoilage of fresh fruits, vegetables and process products. Importance of microorganisms in fermentation processes.

UNIT VI, VII, VIII

Present status and future prospects of preservation industry in India. Principles and methods of preservation; Raw materials for processing. Processing of fruits and vegetables (canning; drying and dehydration; fruit beverages and juice concentrates; sugar based products; tomato products; fermented products, value added products etc.), food additives, minimal processing. Packaging technique and storage system for processed products. Labels. Utilization of byproducts and waste management of processing industry. Preparation of various products from flowers, and dehydrated technique.

UNIT IX & X

Importance of quality, quality management standards, ISO/BIS, PFA, AGMARK, etc.; HACCP, Codex alimentarius, Total quality management (TQM) etc.; Food standards (FPO, PFA etc.). Food laws and regulations.

Practical

Analyzing maturity stages of commercially important horticultural crops, physiological loss in weight of fruits and vegetables, estimation of transpiration, respiration rate, ethylene release and study of vase life extension in cut flower using chemicals; Study of machinery and equipments used in processing of horticultural produce; Preparation of fruit jam, squashes, sauce, pickle; drying of fruits and vegetable etc. Chemical analysis of nutritive value of fresh and processed fruits and vegetables. Visit to cold storage and CA storage units; visit to fruit and vegetable processing units to study the layout, equipments, hygiene, sanitation and residual / waste management.

Learning Outcome:

Students will acquire knowledge on maturity and physiology of ripening, pre and post harvest management techniques, storage and modern packaging and preservation techniques and value addition of fruits, vegetables and ornamental crops.

HOR 505 Technological advancement of fruit, vegetable and ornamental crops 2+0

Objectives:

Students are expected to know about the recent advancement in horticulture and advanced technology like organic horticulture, protected cultivation, biotechnological tools,

micropropagation techniques and their application in the field of fruits, vegetables and ornamental crops.

Syllabus:

Theory

UNIT I, II and III

Organic horticulture – definition, principles, methods, merits and demerits. IFOAM and global scenario of organic movement. Organic farming systems. Components of organic horticultural systems. Different organic inputs, their role in organic horticulture. Sustainable soil fertility management, weed management practices in organic farming, biological/natural control of pests and diseases, organic horticulture in quality improvement. Post-harvest management of organic produce. Certification. Organic horticulture and export.

UNIT IV, V and VI

Objectives, importance and scope of protected cultivation of vegetable, fruits, flowers and ornamental plants. World scenario, Indian situation: present and future. Principles and structures used in protected cultivation including hotbed, cold frame, glasshouse polyhouse, shade net, low tunnels, rain shelters etc. Interaction of light, temperature, humidity, CO₂, water on crop regulation. Greenhouse heating, cooling, ventilation and shading. Containers and substrates, soil decontamination. Water and nutrient management. Automated greenhouses. Management of pest and diseases. Selection of crops and varieties. Recent advancement.

UNIT VII & VIII

Basic principle of plant tissue culture. Commercial application of plant tissue culture with major emphasis on ornamental, fruits and vegetable crops. Basic concept and application of biotechnology in horticultural crops.

UNIT IX & X

Recent advancement in various horticultural technologies.

Learning Outcome:

Students will gather details knowledge on modern advanced technology like micro propagation, precision farming, biotechnological tools, establishment and management of high density orchard etc and their application in horticulture.

HOR 511 Propagation and nursery management in horticultural crops

1+1

Objectives:

Students are expected to gain the knowledge on different aspects of seed propagation and vegetative propagation like cutting, budding, grafting, layering, micro-propagation as well as nursery management.

Syllabus:

Theory

UNIT I

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

UNIT II

Seed quality, packing, storage, certification, testing. Asexual propagation – rooting of soft and hard wood cutting under mist by growth regulators. Rooting of cuttings in hotbeds. Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

UNIT III

Budding and grafting – selection of elite mother plants. Root stock. Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility. Rejuvenation through top working – Progeny orchard and scion bank.

UNIT IV

Micro-propagation – principles, concepts and techniques; commercial exploitation in horticultural crops. Hardening, packing and transport of micro-propagules.

UNIT V

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

Practical

Anatomical studies in rooting of cutting and graft union, study and preparation of media and PGR. Hardening – case studies; various methods of asexual propagation (cutting, budding, grafting etc.); visit to commercial nurseries.

Learning Outcome:

Students will gather theoretical and practical knowledge of different types of sexual and asexual methods of propagation, aspects of micro-propagation and nursery management.

HOR 512 Tropical and dry land fruit production

2+1

Objectives:

Students are expected to know the details of national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, advanced

production system, maturity indices, harvesting, physiological disorders of major tropical and dry land fruits.

Syllabus:

Theory

Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bioregulators, abiotic factors limiting fruit production, physiology of flowering, pollination fruit set and development, honeybees in cross pollination, physiological disorders- causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones(AEZ) and industrial supports.

Crops

UNIT I: Mango and Banana

UNIT II: Citrus and Papaya

UNIT III: Guava, Sapota and Jackfruit

UNIT IV: Pineapple, Annonas and Avocado

UNIT V: Aonla, Pomegranate and Ber, minor fruits of tropics

Practical

Identification of tropical and dry land fruit crops and their important cultivars; observations on growth and development; practices in growth regulation, malady diagnosis, analyses of quality attributes; preparation of layout for orchards; visit to tropical and arid zone orchards.

Learning Outcome:

Students will gather theoretical and practical knowledge of advanced production technology of different tropical fruits like mango, banana, citrus, papaya, guva, sapota etc. and dry land fruits like aonla, pomegranate, ber, pineapple, annona etc.

HOR 513 Subtropical and temperate fruit production

2+1

Objectives:

Students are expected to gather the details knowledge of national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, advanced production system, maturity indices, harvesting, physiological disorders of major subtropical and temperate fruits.

Syllabus:

Theory

Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, bioregulation, abiotic factors limiting fruit production, physiology of flowering, fruit set and development, abiotic factors limiting production, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, precooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones(AEZ) and industrial support.

Crops

UNIT I: Apple, pear, grapes

UNIT II: Plums, peach, cherries

UNIT III: Litchi, loquat, kiwifruit, strawberry

UNIT IV: Nuts- walnut, almond, pistachio

UNIT V: Minor fruits- carambola, bael, wood apple, rambutan, pomegranate

Practical

Identification of sub-tropical and temperate fruit crops and their important cultivars; observations on growth and development; practices in growth regulation, malady diagnosis, analyses of quality attributes; preparation of layout for orchards; visit to tropical, subtropical, humid tropical and temperate orchards,

Learning Outcome:

Students will gather theoretical and practical knowledge of advanced production technology of different subtropical fruits like grapes, litchi, loquat, carambola, bael, rambutan etc. and temperate fruits like apple, pear, peach, cherry, strawberry etc.

HOR 514 Breeding of fruit crops

1+1

Objectives:

Students are expected to know the detail of different basic aspects of fruit breeding like introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding etc. as well as breeding techniques , breeding achievements of different major fruit crops.

Syllabus:

Theory

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding Objectivess, ideotypes, approaches for

crop improvement - introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops.

Crops

UNIT I: Mango, banana and pineapple

UNIT II: Citrus, grapes, guava and sapota

UNIT III: Jackfruit, papaya, custard apple, aonla, avocado and ber

UNIT IV: Mangosteen, litchi, phalsa, mulberry and nuts

UNIT V: Apple, pear, plums, peach and strawberry

Practical

Characterization of germplasm, blossom biology, study of anthesis, estimating fertility status, practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for resistance, developing breeding programme for specific traits, visit to research stations working on tropical, subtropical and temperate fruit improvement.

Learning Outcome:

Students will gather basic knowledge on different aspects of fruit breeding and breeding of different fruits like mango, banana, citrus, grapes, guava, apple, pear, plums etc

HOR 515 Biodiversity and conservation of fruit crops

2+1

Objectives:

Students are expected to gain the knowledge on evolution, centre of origin, centre of diversity, genetic diversity, utilization and conservation strategies of different germplasm of fruit crops.

Syllabus:

Theory

UNIT I

Biodiversity and conservation; issues and goals, centres of origin of cultivated fruits; primary and secondary centres of genetic diversity.

UNIT II

Present status of gene centres; exploration and collection of germplasm; conservation of genetic resources – conservation *in situ* and *ex situ*.

UNIT III

Germplasm conservation- problem of recalcitrancy - cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine.

UNIT IV

Intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group.

UNIT V

GIS and documentation of local biodiversity, Geographical indication.

Crops

Mango, sapota, citrus, guava, banana, papaya, grapes, jackfruit, custard, apple, ber, aonla, malus, *Prunus* sp, litchi, nuts, coffee, tea, rubber, cashew, coconut, cocoa, palmyrah, arecanut, oil palm and betelvine.

Practical

Documentation of germplasm - maintenance of passport data and other records of accessions; field exploration trips, exercise on *ex situ* conservation - cold storage, pollen/seed storage, cryopreservation, may visits to National Gene Bank and other centers of PGR activities. Detection of genetic constitution of germplasm, core sampling, germplasm characterization using molecular techniques.

Learning Outcome:

Students will gather the advanced knowledge on evolution, centre of origin, centre of diversity, genetic diversity, and utilization and conservation strategies of different fruit crops.

HOR 516 Canopy management in fruit crops

1+1

Objectives:

Students are expected to gather the details knowledge of importance, advantages, factors affecting canopy management, canopy structures, light interception in canopy and different methods of canopy management.

Syllabus:

Theory

UNIT I

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

UNIT II

Canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies.

UNIT III

Spacing and utilization of land area - Canopy classification; Canopy management through rootstock and scion.

UNIT IV

Canopy management through plant growth inhibitors, training and pruning and management practices.

UNIT V

Canopy development and management in relation to growth, flowering, fruiting and fruit quality in temperate fruits, grapes, passion fruits, mango, sapota, guava, citrus and ber.

Practical

Study of different types of canopies, training of plants for different canopy types, canopy development through pruning, use of plant growth inhibitors, geometry of planting; study on effect of different canopy types on production and quality of fruits.

Learning Outcome:

Students will gather theoretical and practical knowledge of factors affecting canopy management, canopy structures, light interception in canopy and different methods of canopy management and specific canopy management techniques of major fruit crops.

HOR 517

Biotechnology of horticultural crops

2+1

Objectives:

Students are expected to know the details about tissue culture, bioreactor and secondary metabolite production, somatic hybridization, somaclonal variation, invitro mutagenesis, uses of molecular markers etc.

Syllabus:

Theory

UNIT I

Harnessing bio-technology in horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture.

UNIT II

Callus culture - types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis.

UNIT III

Use of bioreactors and *in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues, ex vitro, establishment of tissue cultured plants.

UNIT IV

Physiology of hardening - hardening and field transfer, organ culture - meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture and fusion.

UNIT V

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 biotechnology in horticultural crops.

Practical

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

Learning Outcome:

Students will gather theoretical and practical knowledge of tissue culture, bioreactor and secondary metabolite production, somatic hybridization, selection against biotic stress, invitro mutgenesis, uses of molecular markers etc.

HOR 518

Organic horticulture

1+1

Objectives:

Students are expected to gain the knowledge on components of organic horticulture system, organic inputs, sustainable natural resource management, organic disease and pest management, standard management and organic certification etc.

Syllabus:

Theory

UNIT I

Organic horticulture – definition, synonyms and misnomers, principles, methods, merits and demerits.

UNIT II

Organic farming systems, components of organic horticultural systems, different organic inputs, their role in organic horticulture, role of biofertilizers, biodynamics and the recent developments.

UNIT III

EM technology and its impact in organic horticulture, indigenous practices of organic farming, sustainable soil fertility management, weed management practices in organic farming, biological/natural control of pests and diseases, organic horticulture in quality improvement.

UNIT IV

GAP - Principles and management, HACCP exercise, certification of organic products and systems, agencies involved at national and international levels, standards evolved by different agencies.

UNIT V

Constraints in certification, organic horticulture and export, IFOAM and global scenario of organic movement, post-harvest management of organic produce.

Practical

Features of organic orchards, working out conversion plan, Input 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, visit to fields cultivated under organic practices.

Learning Outcome:

Students will gather the advanced knowledge on components of organic horticulture system, organic inputs, sustainable natural resource management, organic disease and pest management, standard management and organic certification etc.

HOR 521 Production technology of cool season vegetable crops 2+1

Objectives:

To educate production technology of cool season vegetables.

Syllabus:

Theory

Introduction, origin, distribution and botanical relationship; general morphology and taxonomy; commercial varieties/hybrids, their evaluation and characteristics; basic principles of production

(climatic and soil requirements, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production); specific problem associated in crop production and their solution; nutritive value and uses of:

UNIT I: Potato

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

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

UNIT IV: Bulb crops: onion and garlic

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

UNIT VI: Minor cool season vegetables

Practical

Morphological study and identification of economic part and seed; Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of winter vegetable crops and their economics; Demonstrate the role of mineral elements, plant growth substances and herbicides etc.; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial vegetable growing areas, farm etc.

Learning Outcome:

Students will acquire theoretical knowledge and practical skill on production of cool season vegetable crops.

HOR 522 Production technology of warm season vegetable crops 2+1

Objectives:

To educate production technology of warm season vegetables.

Syllabus:

Theory

Introduction, origin, distribution and botanical relationship; general morphology and taxonomy; commercial varieties/hybrids, their evaluation and characteristics; basic principles of production (climatic and soil requirements, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production); specific problem associated in crop production and their solution; nutritive value and uses of:

UNIT I: Tomato, eggplant, hot and sweet peppers

UNIT II: Okra, beans and cowpea

UNIT III: Cucurbitaceous crops

UNIT IV: Tapioca and sweet potato

UNIT V: Green leafy warm season vegetables

UNIT VI: Minor warm season vegetables

Practical

Morphological study and identification of economic part and seed; Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of winter vegetable crops and their economics; Demonstrate the role of mineral elements, plant growth substances and herbicides etc.; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial vegetable growing areas, farm etc.

Learning Outcome:

Students will acquire theoretical knowledge and practical skill on production of warm season vegetable crops.

HOR 523

Breeding of vegetable crops

2+1

Objectives:

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

Syllabus:

Theory

UNIT I

Importance, history and evolutionary aspects of vegetable breeding; breeding systems and methods; brief account on breeding through selection, hybridization, heterosis breeding, male sterility, self-incompatibility etc.

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

UNIT II: Potato

UNIT III: Tomato, eggplant

UNIT IV: Hot pepper, sweet pepper and okra

UNIT V: Peas and beans, amaranth, chenopods and lettuce

UNIT VI: Gourds, melons, pumpkins and squashes

UNIT VI: Cabbage, cauliflower,

UNIT VII: Carrot, beetroot, radish,

UNIT IX: Sweet potato and tapioca

UNIT X: Plant variety protection (PVP), International Union for Protection of New Varieties of Plants (UPOV), Issue of patenting, PPVFR act etc.

Practical

Observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations; flowering and palanological studies; selfing and crossing techniques in vegetable crops; hybrid seed production of vegetable crops; screening techniques for insect-pests, disease and environmental stress resistance; demonstration of sib-mating and mixed population; analysis of biometrical problems; Visit to breeding blocks, research stations.

Learning Outcome:

Students will acquire theoretical knowledge on breeding principles, understand vegetable breeding methods and developed the required practical skills on vegetable germplasm handling and breeding work.

HOR 524 Seed production technology of vegetable crops

2+1

Objectives:

To impart a comprehensive knowledge of seed and planting material production in vegetable crops with adequate practical training.

Syllabus:

Theory

UNIT I

Definition of seed and its quality; floral biology, pollination, breeding behaviour, seed development and maturation. Scope of vegetable seed industry in India.

UNIT II

Genetical and agronomical principles of seed production; methods of seed production; methods of hybrid seed production. Use of growth regulators and chemicals in vegetable seed production;

UNIT III

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 IV, V, VI

Agro-techniques for seed production in solanaceous vegetables, cucurbits, leguminous vegetables, cole crops, bulb crops, leafy vegetables, okra, vegetatively propagated vegetables.

UNIT VII

Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards. Testing, releasing and notification procedures of varieties.

UNIT VIII

Seed act and law enforcement, plant quarantine and quality control; new seed policies; DUS test; impact of PVP on growth of seed industry.

Practical

Seed sampling, seed testing (physical purity, genetic purity, seed viability, seed germination seedling vigour and seed health); floral biology; rouging of off-type; methods of hybrid seed production in important vegetable crops; seed extraction techniques; handling of seed processing and seed testing equipments; visit to seed processing units, seed testing laboratory and seed production farms.

Learning Outcome:

Students will acquire adequate theoretical knowledge and practical skills on vegetable seed and planting material production.

HOR 525 Systematics of vegetable crops

1+1

Objectives:

To teach morphological, cytological and molecular taxonomy of vegetable crops.

Syllabus:

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 and description of vegetable species and varieties; collection of allied species and genera locally available; preparation of keys to the species and varieties; methods of preparation of herbarium and specimens.

Learning Outcome:

Students will acquire theoretical knowledge and practical skills on taxonomy of vegetable crops.

HOR 526 Production technology of underexploited vegetable crops 2+1

Objectives:

To educate production technology of underutilized vegetable crops.

Syllabus:

Theory

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

UNIT I

Asparagus, artichoke and leek

UNIT II

Brussels's sprout, Chinese cabbage, broccoli, kale and artichoke.

UNIT III

Amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathua (chenopods) and chekurmanis.

UNIT IV

Elephant foot yam, lima bean, winged bean, vegetable pigeon pea, jack bean and sword bean.

UNIT V

Sweet gourd, spine gourd, pointed gourd, Oriental pickling melon and little gourd (kundru).

Practical

Identification of seeds; botanical description of plants; layout and planting; cultural practices; short-term experiments of underexploited vegetables.

Learning Outcome:

Students will acquire theoretical knowledge and practical skill on production of underexploited vegetable crops.

HOR 527 Organic vegetable production technology

1+1

Objectives:

To educate principles, concepts and production of organic farming in vegetable crops.

Syllabus:

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, Panchagavya, Biodynamics, preparation etc Pest and disease management in organic farming; ITK's in organic farming. Role of botanicals and bio-control agents.

UNIT V

GAP and GMP- Certification of organic products; organic production and export - opportunity and challenges.

Practical

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

Learning Outcome:

Students will acquire theoretical knowledge on organic farming concepts and principles. They will also develop the practical skills for organic vegetable production.

HOR 528**Fundamentals of processing of vegetables****2+1****Objectives:**

To educate principles and practices of processing of vegetable crops.

Syllabus:**Theory**

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Quality assurance and quality control, TQM, GMP. Food standards – FPO, PFA, etc. Food laws and regulations.

UNIT V

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

UNIT VI

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

UNIT VII

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

Practical

Study of machinery and equipments used in processing of horticultural produce; Chemical analysis for nutritive value of fresh and processed vegetables; Sensory evaluation of fresh and processed vegetables; Visit to processing units to study the layout, equipments, hygiene, sanitation and residual / waste management.

Learning Outcome:

Students will acquire theoretical knowledge on principles and methods of processing. They will also develop the practical skills for vegetable processing.

HOR 531 Fundamentals of floriculture and landscape architecture 2+1

Objectives:

Students will get acquainted with fundamentals of floriculture, flower production and its trade. A brief outline of production technology of selected ornamental plants and value addition of flowers. Landscaping and fundamental knowledge about the types and styles of garden and its components along with use of various plants.

Syllabus:

Theory

UNIT I

Global and national scenario of flower production and trade; Propagation, sexual and asexual propagation methods, propagation in mist chambers; nursery management, pro-tray nursery under shadenets; transplanting techniques.

UNIT II

Types of gardens (English, Mughal, Japanese etc.); styles of garden (formal, informal and free style gardens); Special types of gardens (roof garden, bog garden, rock garden etc.)

UNIT III & IV

Landscape designs; Urban landscaping, landscaping for specific situations; Garden plant components, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds.

UNIT V

Turfing and turf management.

UNIT VI

Production technology for selected ornamental plants.

UNIT VII

Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening etc.

UNIT VIII

Value addition in flowers: Types of value added products; Value addition in loose flowers and cut flowers; flower arrangement; Dry flowers; Concrete and essential oils; Types of pigments, significance of natural pigments, extraction methods and Applications.

Practical

Identification of flowers, garden plants, garden implements etc.; preparation of layout and schemes for gardens; preparation of rooting media; potting and repotting; propagation techniques of flower and garden plants; economic analysis; visit to commercial flower growing areas, nurseries etc. Techniques in flower arrangement and floral decoration; Practices in preparation of bouquets, flower baskets, corsages, garlands etc. with fresh flowers; Practices in dry flower making; Preparation of dry flower baskets, bouquets etc.

Learning Outcome:

The students are expected to learn about identification of plants and garden tools, propagation of plants and value added flower products. Visit to commercial flower growing areas, nurseries and preparation of layout and schemes for gardens are necessary for understanding of landscaping at field level.

HOR 532 Production technology of cut flowers

2+1

Objectives:

Acquaintance with scope of global trade of cut flower under available varietal wealth and diversity is necessary for undertaking open and protected cultivation of different cut flowers and its related problems. Understanding of various grades of cut flower and post-harvest handling, packing, storage and transportation are necessary to get idea about its marketing and export.

Syllabus:

Theory

UNIT I

Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India.

UNIT II

Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and CO₂ on growth and flowering.

UNIT III

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

UNIT IV

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

UNIT V

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

Crops: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, liliiums, bird of paradise, heliconia, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliage and fillers.

Practical

Identification and botanical description of species and varieties; propagation techniques, mist chamber operation; training and pruning techniques; practices in manuring, irrigation, foliar nutrition, growth regulator application, pinching, disbudding, staking; harvesting techniques; post-harvest handling, project preparation for regionally important cut flowers, visit to commercial cut flower units and case study.

Learning Outcome:

Above mentioned theoretical part should be supported with learning of identification of species and varieties, propagation and cultural techniques for growing and post-harvest handling of cut flowers reinforced with visit to commercial cut flower units.

HOR 533

Production technology of loose flowers

2+1

Objectives

To impart theoretical information about scope, significance and production of loose flowers and its trade in domestic market and for export with available varietal wealth and diversity. This is supplemented with flower forcing, post-harvest handling, packing storage, value addition, transportation and marketing.

Syllabus:

Theory

UNIT I

Scope of loose flower trade, Significance in the domestic market/export, Varietal wealth and diversity, propagation,

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

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

Practical

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

Learning Outcome:

The students should get practical experience about identification of species and varieties, propagation and cultural techniques for growing and post-harvest handling of loose flowers reinforced with field visit and markets.

Objectives:

To impart theoretical knowledge about origin, distribution, genetic resources, genetic divergence of various flower crops, genetic inheritance of various characters, breeding methods, their constraints and achievements made in different ornamental plants.

Syllabus:**Theory**

UNIT I

Origin, distribution, genetic resources, genetic divergence of various flower crops and ornamental plants; Evolution of varieties.

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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.

Practical

Identification and description of botanical features of cultivars, varieties and species in flowers; floral biology; selfing and crossing technique; 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.

Learning Outcome:

To impart practical experience on identification and description of botanical features of cultivars, varieties and species in flowers, floral biology; selfing and crossing technique, induction of

mutants through physical and chemical mutagens, screening of plants for biotic, abiotic stresses etc.

HOR 535 Landscaping and ornamental gardening 2+1

Objectives:

Students are expected to know the types of garden, types of landscaping, garden components, special gardens etc.

Syllabus:

Theory

UNIT I

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

UNIT II

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

UNIT III

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.

UNIT IV

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

UNIT V

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

Practical

Selection of ornamental plants, practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens, burlapping, lawn making, planting herbaceous and shrubbery borders,

environmental control systems, practices in drip and fertigation techniques, special horticultural practices, determination of harvest indices and harvesting methods, postharvest handling, packing methods, project preparation, visit to commercial greenhouses.

Learning Outcome:

Students will gather theoretical and practical knowledge on types, layout, features of different protective structures suitable for flower crop cultivation, environmental manipulation inside protective structures, growing media, crop regulation, harvesting and postharvest handling etc.

HOR 537

Value addition in flowers

2+1

Objective:

Students are expected to gain the knowledge on types of value added floral products, aspects of dry flowers, floral arrangement, extraction of essential oil and pigments.

Syllabus:

Theory

UNIT I

Prospects of value addition, National and global scenario, production and exports, Women empowerment through value added products making, supply chain management.

UNIT II

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

UNIT III

Dry flowers- Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making - Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement - dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage.

UNIT IV

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

Practical

Practices in preparation of bouquets, 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.

Learning Outcome:

Students will gather the advanced knowledge on various types of value added floral products, aspects and methods of dry flowers preparation, floral arrangement and its types, extraction of essential oil and types of pigments and their extraction.

HOR 538 Turfing and turf management

2+1

Objectives:

Students are expected to know the properties of soil for turfing, types of turf grasses, turf establishment methods, management of turf, establishment and management of turf for play grounds etc.

Syllabus:

Theory

UNIT I

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.

UNIT II

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

UNIT III

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

UNIT IV

Turf management - Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing: mowing equipments,

techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs.

UNIT V

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

Practical

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

Learning Outcome: Students will gather the detail knowledge on physical and biological properties of soil for turfing, different types and characters of turf grasses, turf establishment methods, management of turf, establishment and management of turf for play grounds etc.

HOR 539

CAD for outdoor and indoor scaping

2+1

Objectives:

Students are expected to know the detail about application of CAD in 2D and 3D garden plant and non plant gardening component design using AUTOCAD, ARCHICAD, operation of AUTOCAD for 2D, basics and operation of ARCHICAD for 3D design etc.

Syllabus:

Theory

UNIT I

Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing.

UNIT II

2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects.

UNIT III

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

UNIT IV

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

UNIT V

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

Practical

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

Learning Outcome:

Students will gather theoretical and practical knowledge of application of CAD in 2D and 3D garden plant and non plant gardening component design using AUTOCAD, ARCHICAD, operation of AUTOCAD for 2D, basics and operation of ARCHICAD for 3D design etc.

HOR 591: Credit seminar

HOR 599: Master's research (Thesis)