



**SIKKIM UNIVERSITY**  
**Department of Horticulture**

**Masters' Programme in Horticulture**  
**MSc (Horticulture)**

**Revised Syllabus 2020**

**ORGANIZATION OF COURSE CONTENTS & CREDIT  
REQUIREMENTS FOR MASTER IN HORTICULTURE**

**Credit Requirements**

Subject	Credit Allotted
Major	33
Minor	09
Compulsory	07
Research/Thesis	20
<b>Total Credits</b>	<b>69</b>

**Major subject:** The subject in which the students want specialization.

**Minor subject:** The subject closely related to students major subject.

**Compulsory Courses:** The courses are relevant supporting major subjects.

**Course Structure**

Code	Course Title	Credits	Semester
<b>Major courses specialization wise</b>			
<b>Fruit Science</b>			
HOR PG 501	Tropical and Dry Land Fruit Production	2+1	II
HOR PG 502	Subtropical and Temperate Fruit Production	2+1	II
HOR PG 503	Biodiversity and Conservation of Fruit Crops	2+1	II
HOR PG 504	Breeding of Fruit Crops	2+1	III
HOR PG 505	Propagation and Canopy Management of Fruit Crops	2+1	III
<b>Vegetable Science</b>			
HOR PG 511	Production Technology of Cool Season Vegetable Crops	2+1	II
HOR PG 512	Production Technology of Warm Season Vegetable Crops	2+1	II
HOR PG 513	Breeding of Vegetable Crops	2+1	II
HOR PG 514	Seed Production Technology of Vegetable Crops	2+1	III
HOR PG 515	Production Technology of Under Exploited Vegetable Crops	2+1	III
<b>Floriculture &amp; Landscaping</b>			
HOR PG 521	Breeding and Seed production of Flower Crops and Ornamental Plants	2+1	II
HOR PG 522	Production Technology of Cut Flowers	2+1	II
HOR PG 523	Production Technology of Loose Flowers	2+1	II
HOR PG 524	Landscaping and Ornamental Gardening	2+1	III
HOR PG 525	Turfing and Turf Management	2+1	III
<b>Plantation, Spices, Medicinal and Aromatic plants</b>			
HOR PG 531	Production of Plantation Crops	2+1	II

HOR PG 532	Production Technology of Spice Crops	2+1	II
HOR PG 533	Production Technology of Medicinal And Aromatic Crops	2+1	II
HOR PG 534	Breeding of Plantation Crops and Spices	2+1	III
HOR PG 535	Breeding of Medicinal and Aromatic Crops	2+1	III
<b>Common Major Courses for All students</b>			
HOR PG 541	Post Harvest Technology for Horticultural Crops	2+1	I
HOR PG 542	Growth Regulation of Horticultural Crops	2+1	I
HOR PG 543	Protected Cultivation of Horticulture Crops	2+1	I
HOR PG 544	Biotechnology for Crop Improvement	2+1	I
HOR PG 545	Organic Horticulture and GAP	2+1	I
HOR PG 546	Experimental Designs	2+1	I
<b>Compulsory Supportive Courses for All students</b>			
HOR PG 571	Intellectual Property and Its Management In Agriculture	1+0	I
HOR PG 572	Basic Concepts In Laboratory Techniques	0+1	I
HOR PG 573	Library and Information Services	0+1	III
HOR PG 574	Technical Writing and Communications Skills	0+1	III
HOR PG 575	Agricultural Research, Research Ethics and Rural Development Programmes	1+0	II
HOR PG 576	Disaster Management	1+0	II
HOR PG 590	Master's Seminar	0+1	III
HOR PG 591	Master's Research	20	IV
HOR PG 592	Comprehensive Examination**	0	IV
<b>Minor Courses</b>			
HOR PG 561*	Plant Physiology I	3	II
HOR PG 562*	Plant Physiology II	2+1	II
HOR PG 563*	Plant Physiology III	2+1	II
HOR PG 564#	Plant Protection I	2+1	II
HOR PG 565#	Plant Protection II	2+1	II
HOR PG 566#	Plant Protection III	2+1	II
HOR PG 567^	Genetic and Plant Breeding I	2+1	II
HOR PG 568^	Genetic and Plant Breeding II	2+1	II
HOR PG 569^	Genetic and Plant Breeding III	2 +1	II

A student majoring in Horticulture has to select any one subject specialization i.e. Fruits Science/ Floriculture & Landscaping/ Vegetable Science/ Plantation, Spices, Medicinal & Aromatic Plants and all the courses of concerned specialization is compulsory.

He/ She can opt for any other specialization courses as minor from the given list. All the students have to take compulsory supportive courses.

\*#^ courses are suppose to take together.

\*\* Comprehensive examination is compalsury to submit the thesis. Qualifying marks is 60%.

### **Semester wise credit distribution**

<b>Semester</b>	<b>Credits</b>
First	20
Second	20
Third	09
Fourth**	20
Total Credits	69
Thesis works starts by third semester	

**\*\*Note : Compulsory Comprehensive exam will be held at the bening of the fourth semester. Students needs to qualify comprehensive exam to submit the thesis. Qualifying marks is 60%.**

# FRIUT SCIENCE

## **HOR PG 501 TROPICAL AND DRYLAND FRUIT PRODUCTION**

**(2+1)**

### **Theory**

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, rootstock influence, 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**

**UNIT I** :Mango, Banana,Citrus and Papaya

**UNIT II**: Guava, Sapota and Jackfruit

**UNIT III**:Pineapple, Annonas and Avocado

**UNIT IV**: Aonla, Pomegranate, Phalsa, Ber and minor fruits of tropics

### **Practical**

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

### **Suggested Readings**

- Bose TK, Mitra SK & Sanyal D. 2001. (Eds.). *Fruits -Tropical and Subtropical*. Naya Udyog.
- Chadha KL & Pareek OP. 1996. (Eds.) *Advances in Horticulture*. Vols.II- IV. Malhotra Publ. House. NakasoneHY & Paul RE. 1998. *Tropical Fruits*. CABI.
- Peter, KV. 2008. (Ed.) *Basics of Horticulture*. New India Publ. Agency.
- Pradeep Kumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops*. Parts I,II. New India Publ. Agency.
- Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.
- Salunkhe, D K & Kadam S S. 2013. *Handbook of Fruit science and Technology*. CRC Press.
- Singh HP, Negi JP & Samuel JC. (Eds.). 2002. *Approaches for Sustainable Development of Horticulture*. National Horticultural Board.
- Singh HP, Singh G, Samuel JC & Pathak RK. (Eds.) 2003. *Precision Farming in Horticulture*. NCPAH, DAC/PFDC, CISG, LUCKNOW.

## **HOR PG 502 SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION (2+1)**

### **Theory**

Commercial varieties of regional, national and international importance, eco physiological 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, pre cooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones (AEZ) and industrial support.

### **Crops**

**UNIT I:** Apple, pear, quince, plums, peach, apricot, cherries, kiwifruit and strawberry

**UNIT II:** Minor fruits- mangosteen, carambola, bael, wood apple, jamun and fig

**UNIT III:** Litchi, grapes, loquat, pomegranate and persimmon

**UNIT IV:** Nuts- walnut, almond, pistachio, pecan, hazle nut

### **Practical**

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

### **Suggested Readings**

- Bal, J S. 2015. Fruit Growing 3rd Ed. Kalyani Publishers
- Bose TK, Mitra SK & Sanyol D. (Ed.). 2002. Fruits of India – Tropical and Sub tropical. 3 Ed. Vols. I,II. Naya Udyog
- Bose TK, Mitra SK & Rathore DS. (Eds.). 1988. *Temperate Fruits - Horticulture*. Allied Publ.
- Chadha KL & Pareek OP. 1996. (Eds.) *Advances in Horticulture*. Vol. I. Malhotra Publ. House.
- Chadha KL & Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House.
- Radha T & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.

## **HOR PG 503 BIODIVERSITY AND CONSERVATION OF FRUITCROPS (2+1)**

### **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 colds storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine.

## **UNIT IV**

Intellectual propertyrights, 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,nuts,coffee,tea,rubber,cashew, coconut, cocoa, palmyrah, arecanut, oil palmand betelvine.

### **Practical**

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

### **SuggestedReadings**

- Frankel OH & Hawkes JG. 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press.
- Peter KV & Abraham Z. 2007. *Biodiversity in Horticultural Crops*. Vol. I. Daya Publ. House.
- Peter KV. 2008 *.Biodiversity of Horticultural Crops*.Vol. II. Daya Publ. House.
- Malik, S. K. 2010 Genetic resources of tropical underutilised fruits in India
- B C Mazumdar 2004. *Minor Fruit Crops of India : Tropical and Subtropical*. Daya Publishing House, Delhi.

**HOR PG 504 BREEDING OF FRUIT CROPS**

**(2+1)**

### **Theory**

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic

resources, blossom biology, breeding systems, breeding objectives, 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 ,Citrus, grapes, guava and pineapple

**UNIT II**: Litchi, sapota, jackfruit, papaya, avocado, and custard

**UNIT III**: Aonla, mangosteen, jamun, phalsa,and ber

**UNIT IV**: Apple, pear, plums, peach, apricot, cherries,straw berry and mulberry.

### **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

### **Suggested Readings**

- Chadha KL & Pareek OP. 1996. (Eds.) *Advances in Horticulture*. Vol. I. Malhotra Publ. House.
- Bose TK, Mitra SK & Sanyo ID. (Eds.). 2002. *Fruits of India – Tropical and Sub tropical 3rd Ed. Vols. I, II*. Naya Udyog.
- Janick J & Moore JN. 1996. *Fruit Breeding*. Vols. I-III. John Wiley & Sons. Nijjar GS. 1977. (Eds.). *Fruit Breeding in India*.Oxford & IBH.
- RadhaT & Mathew L. 2007. *Fruit Crops*. New India Publ. Agency.
- Ramachandran RK, Nachegowda V , M K Honnabyroiah 2015. *Breeding of Fruit Crops*. Jaya Publishing.
- Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.) 2004. *Advances in Citriculture*. Jagminder Book Agency.

## **HOR PG 505 Propagation and Canopy Management for Fruit Crops (2+1)**

### **Objective**

To impart knowledge about the principles and practices in canopy management of fruit crops. Familiarization with principles and practices of propagation and nursery management for fruit crops.

### **Theory**

**UNIT I**: 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 inhibitors, training and pruning and management practices. Canopy development and management in relation to growth, flowering, fruiting and fruit quality in temperate fruits, grapes, passion fruits, mango, sapota, guava, citrus and ber.

**UNIT II:** 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. Seed quality, treatment, packing, storage, certification, testing.

**UNIT III:** 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. Budding and grafting – selection of elite mother plants, methods. 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 and concepts, commercial exploitation in horticultural crops. Techniques - *in vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture. Hardening, packing and transport of micro-propagules.

### **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.

Anatomical studies in rooting of cutting and graft union, construction of propagation structures, study of media and PGR. Hardening – case studies, micropropagation, explant preparation, media preparation, culturing – *in vitro* clonal propagation, meristem culture, shoot tip culture, axillary bud 15 culture, direct organogenesis, direct and indirect embryogenesis, micro grafting, hardening.

### **Suggested Readings**

- Pradeep kumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops*. New India Publ. Agency.
- Hartmann HT & Kester DE. 1989. *Plant Propagation – Principles and Practices*. Prentice Hall of India.
- Bose TK, Mitra SK & Sadhu MK. 1991. *Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash.
- Peter KV. (Ed.). 2008. *Basics of Horticulture*. New India Publ. Agency. Singh SP. 1989 *Mist Propagation*. Metropolitan Book Co.
- Rajan S & Baby LM. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency.

# FLORICULTURE & LANDSCAPING

## **HOR PG 521 BREEDING AND SEED PRODUCTION OF FLOWER CROPS AND ORNAMENTAL PLANTS**

(2+1)

### **Theory**

#### **UNIT I**

Principles—Evolution of varieties, origin, distribution, genetic resources, genetic divergence—Patents and Plant Variety Protection in India. Genetic inheritance—offlower colour, doubleness, flowersize, fragrance, post harvest life.

#### **UNIT II**

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 III**

Breeding constraints and achievements made in commercial flowers like rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster, heliconia, lilioms, nerium and ornamental plants like – petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snapdragon, pansy) and ornamental foliage

#### **UNIT IV**

Definition of seed and its quality, new seed policies ; DUS test, Genetical and agronomical principles of seed production; methods of seed production; Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control. Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/packets), storage and cryopreservation of seeds, synthetic seed technology.

### **Practical**

Description of botanical features—Cataloguing of cultivars, varieties and species in flowers, floral biology, selfing and crossing, evaluation of hybrid progenies, seed production—Induction of mutants through physical and chemical mutagens, induction of polyploidy, screening of plants for biotic, abiotic stresses and environmental pollution, *invitro* breeding in flower crops and ornamental plants. Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, physical purity) and seed health testing; rouging of off-type; seed extraction techniques; handling of seed processing and seed testing equipments; seed sampling

### **Suggested Readings**

- Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.
- Bose TK & Yadav LP. 1989. *Commercial Flowers*. Naya Prokash.
- Chadha KL & Choudhury B. 1992. *Ornamental Horticulture in India*. ICAR.
- Chadha KL. 1995. *Advances in Horticulture*. Vol. XII. Malhotra Publ. House.
- Chaudhary RC. 1993. *Introduction to Plant Breeding*. Oxford & IBH.
- Singh BD. 1990. *Plant Breeding*. Kalyani.
- Agrawal PK & Dadlani M. (Eds.). 1992. *Techniques in Seed Science and Technology*. South Asian Publ.
- Agrawal RL. (Ed.). 1997. *Seed Technology*. Oxford & IBH.

## **HOR PG 522 PRODUCTION TECHNOLOGY OF CUT FLOWERS**

**(2+1)**

### **Theory**

#### **UNIT I**

Scope of cut flowers industry in national and international trade ; National and International scenario of cut flower production; Varietal wealth and diversity, Area under cut flowers production; Problems in cut flower industry in India ; Govt. initiatives to resolve those problems, Marketing, Export potential, Institutional support, Agri Export Zones for cut flowers.

#### **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 CO<sub>2</sub> on growth and flowering of cut flower crops. Water and nutrient management, fertigation, weed management, rationing, training and pruning, disbudding, special horticultural practices

#### **UNIT III**

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. Nursery management, media for nursery, special nursery practices.

#### **UNIT IV**

Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, Storage & transportation for the following cut flowers:

**Crops:** Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthurium, aster, liliams, birdofparadise, heliconia, alstroemeria, ornamental ginger, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliage and fillers.

### **Practical**

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

### **Suggested Readings**

- Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.
- Bose TK & Yadav LP. 1989. *Commercial Flowers*. Naya Prokash.
- Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash.
- Chadha KL & Chaudhury B. 1992. *Ornamental Horticulture in India*. ICAR.
- Chadha KL. 1995. *Advances in Horticulture*. Vol. XII. Malhotra Publ. House.
- Lauria A & Ries VH. 2001. *Floriculture—Fundamentals and Practices*. Agrobios.
- Prasad S & Kumar U. 2003. *Commercial Floriculture*. Agrobios.
- Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.
- Reddy S, Janakiram B, Balaji T, Kulkarni S & Misra RL. 2007. *Hightech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi.

## **HOR PG 523 PRODUCTION TECHNOLOGY FOR LOOSE FLOWERS**

(2+1)

### **Theory**

#### **UNIT I**

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

#### **UNIT II**

Soil and climate requirements, field preparation, systems of planting, precision farming techniques. Water and nutrient management, weed management, rationing, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM.

#### **UNIT III**

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

## UNIT IV

Harvest indices, harvesting techniques, post-harvest handling and grading, pre-cooling, packing and storage, value addition, concrete and essential oil extraction, transportation for following crops:

**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

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

### Suggested Readings

- Bhattacharjee SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.
- Bose TK & Yadav LP. 1989. *Commercial Flowers*. Naya Prokash.
- Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash.
- Chadha KL & Chaudhury B. 1992. *Ornamental Horticulture in India*. ICAR.
- Chadha KL. 1995. *Advances in Horticulture*. Vol. XII. Malhotra Publ. House.
- Lauria A & Ries VH. 2001. *Floriculture—Fundamentals and Practices*. Agrobios.
- Prasad S & Kumar U. 2003. *Commercial Floriculture*. Agrobios.
- Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.
- Sheela VL. 2007. *Flowers in Trade*. New India Publ. Agency.

## HOR PG 524 LANDSCAPING AND ORNAMENTAL GARDENING

(2+1)

### Theory

#### UNIT I

Definitions – Landscaping, Landscape designs, Landscape gardening, Landscape architect; Styles of garden - formal, informal and free style gardens; Types of gardens- English, Mughal, Japanese, Persian, Spanish, Italian, Vanams (Hindu), Buddha garden.

#### UNIT II

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; Non-plant components Production technology

for selected ornamental plants.

### **UNIT III**

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

### **UNIT IV**

Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporates. Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, waterscaping, xeriscaping, hardscaping.

### **Practical**

Identification of ornamental plants. Understanding colour themes for design preparation, Drawing tools for design preparation; Graphic languages for design preparation; practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens, overlapping, lawn making, planting herbaceous and shrubbery borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

### **Suggested Readings**

- Bhattcharjee S K. 2004. Landscape Gardening & Design With Plants, Aavishkar Publishers Distributors
- Bose TK, Maiti RG, Dhua RS & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash.
- Lauria A & Victor HR. 2001. *Floriculture—Fundamentals and Practices* Agrobios.
- Nambisan KMP. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH.
- Randhawa GS & Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.
- Sabina GT & Peter KV. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency.
- Woodrow MG. 1999. *Gardening in India*. Biotech Books.

## **HOR PG 525 TURFING AND TURF MANAGEMENT**

**(2+1)**

### **Theory**

### **UNIT I**

Prospects of landscape and turf 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**

Turfgrasses- 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.

### **UNIT III**

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

### **UNIT IV**

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 topdressing, 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.

### **Suggested Readings**

- Lauria A & Victor HR. 2001. *Floriculture – Fundamentals and Practices* Agrobios.
- Christians N E 2007. *Fundamentals of Turfgrass Management*. John Wiley & Sons, Inc
- Turgeon A J 2011. *Turfgrass Management*. 8<sup>th</sup> Edition. Reston Publishing Company, Inc
- Mohammad Pessarakli 2007. *Handbook of Turfgrass Management and Physiology*, CRC Press.
- Emmons R and Rossi F 2016. *Turfgrass Science and Management* 5<sup>th</sup> edition, Cengage learning, USA.

# VEGETABLE SCIENCE

## CourseContents

### HOR PG 511 PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS

(2+1)

#### Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/ hybrids, sowing/ planting time 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 :** Colecrops: cabbage, cauliflower, knolkohl, sprouting broccoli, Brussels sprout

**UNIT II :** Root and tuber crops: carrot, radish, turnip and beetroot

**UNIT III:** Bulbcrops: onion and garlic and Potato

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

#### Practical

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

#### Suggested Readings

- Bose TK & Som MG. (Eds.). 1986. *Vegetable Crops in India*. Naya Prokash.
- Bose TK, Som G & Kabir J. (Eds.). 2002. *Vegetable Crops*. Naya Prokash. Bose TK, Som MG & Kabir J. (Eds.). 1993. *Vegetable Crops*. Naya Prokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. *Vegetable Crops*. Vols. I-III. Naya Udyog.
- Chadha KL & Kalloo G. (Eds.) 1993-94. *Advances in Horticulture* Vols.V-X. Malhotra Publ. House.
- Chadha KL. (Ed.) 2002. *Hand Book of Horticulture*. ICAR.
- Chauhan DVS. (Ed.) 1986. *Vegetable Production in India*. Ram Prasad & Sons.
- Decoteau DR. 2000. *Vegetable Crops*. Prentice Hall.
- Fageria MS, Choudhary BR & Dhaka RS. 2000. *Vegetable Crops: Production Technology*. Vol. II. Kalyani.
- Gopalakrishnan TR. 2007. *Vegetable Crops*. New India Publ. Agency.

- Hazra P & Som MG. (Eds.) 1999. *Technology for Vegetable Production and Improvement*. Naya Prokash.
- Rana MK. 2008. *Olericulture in India*. Kalyani Publ.
- Rana MK. 2008. *Scientific Cultivation of Vegetables*. Kalyani Publ.
- Rubatzky VE & Yamaguchi M. (Eds.) 1997. *World Vegetables: Principles, Production and Nutritive Values*. Chapman & Hall.
- Thamburaj S & Singh N. (Eds.) 2004. *Textbook on Vegetables, Tuber Crops and Spices*. ICAR.
- Thompson HC & Kelly WC (Eds.) 1978. *Vegetable Crops*. Tata McGraw- Hill.

## **HOR PG 512 PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS (2+1)**

### **Theory**

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

**UNIT I :** Tomato, eggplant, hot and sweet peppers

**UNIT II :** Okra, beans, cowpea and clusterbean, Green leafy warm season vegetables

**UNIT III :** Cucurbitaceous crops

**UNIT IV :** Tapioca and sweet potato

### **Practical**

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of summer vegetable crops and their economics; study of physiological disorders and deficiency of mineral elements, preparation of cropping schemes for commercial farms; experiments to demonstrate the role of mineral elements, physiological disorders; plant growth substances and herbicides; seed extraction techniques; identification of important pests and diseases and their control; maturity standards; economics of warm season vegetable crops.

### **Suggested Readings**

- Bose TK & Som MG. (Eds.). 1986. *Vegetable Crops in India*. Naya Prokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. *Vegetable Crops*. Vols. I-III. Naya Udyog.

- Bose TK, Som MG & Kabir J. (Eds.). 2002. *Vegetable Crops*. Naya Prokash.
- Brown HD & Hutchison CS. *Vegetable Science*. JB Lippincott Co.
- Chadha KL & Kalloo G. (Eds.). 1993-94. *Advances in Horticulture*. Vols.V-X. Malhotra Publ. House.
- Chadha KL. (Ed.). 2002. *Hand Book of Horticulture*. ICAR.
- Chauhan DVS. (Ed.) 1986. *Vegetable Production in India*. Ram Prasad & Sons.
- Fageria MS, Choudhary BR & Dhaka RS. 2000. *Vegetable Crops: Production Technology*. Vol. II. Kalyani.
- Gopalakrishnan TR. 2007. *Vegetable Crops*. New India Publ. Agency.
- Hazra P & Som MG. (Eds.) 1999. *Technology for Vegetable Production and Improvement*. Naya Prokash.
- Kalloo G & Singh K (Ed.). 2000. *Emerging Scenario in Vegetable Research and Development*. Research-Periodicals & Book Publ. House.
- Nayer NM & More TA 1998. *Cucurbits*. Oxford & IBH Publ. Palaniswamy & Peter KV. 2007. *Tuber Crops*. New India Publ. Agency.
- Pandey AK & Mudranalay V. (Eds.). *Vegetable Production in India: Important Varieties and Development Techniques*.
- Rana MK. 2008. *Olericulture in India*. Kalyani.
- Thamburaj S & Singh N. 2004. *Vegetables, Tuber Crops and Spices*. ICAR.
- Thompson HC & Kelly WC. (Eds.) 1978. *Vegetable Crops*. Tata McGraw Hill.

## **HOR PG 513 BREEDING OF VEGETABLE CROPS**

**(2+1)**

### **Theory**

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

**UNIT I:** Potato, tomato, eggplant, hot pepper, sweet pepper and okra

**UNIT II :** Peas and beans, amaranth, chenopods and lettuce

**UNIT III :** Gourds, melons, pumpkins and squashes

**UNIT IV :** Cabbage, cauliflower, carrot, beetroot, radish, sweet potato and tapioca

### **Practical**

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

### **Suggested Readings**

- Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons.
- Basset MJ. (Ed.). 1986. *Breeding Vegetable Crops*. AVI Publ.
- Dhillon BS, Tyagi RK, Saxena S. & Randhawa GJ. 2005. *Plant Genetic Resources: Horticultural Crops*. Narosa Publ. House.
- Fageria MS, Arya PS & Choudhary AK. 2000. *Vegetable Crops: Breeding and*
- Hayes HK, Immer FR & Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.
- Kalloo G. 1998. *Vegetable Breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
- Paroda RS & Kalloo G. (Eds.) 1995. *Vegetable Research with Special Reference to Hybrid Technology in Asia-Pacific Region*. FAO.
- Peter KV & Pradeep Kumar T. 2008. *Genetics and Breeding of Vegetables*. Revised, ICAR.
- Rai N & Rai M. 2006. *Heterosis Breeding in Vegetable Crops*. New India Publ. Agency.
- Ram HH. 1998. *Vegetable Breeding: Principles and Practices*. Kalyani.
- Singh BD. 1983. *Plant Breeding*. Kalyani.
- Singh PK, Dasgupta SK & Tripathi SK. 2004. *Hybrid Vegetable Development*. International Book Distributing Co.
- Swarup V. 1976. *Breeding Procedure for Cross-pollinated Vegetable Crops*. ICAR.

## **HOR PG 514 SEED PRODUCTION TECHNOLOGY OF VEGETABLE CROPS**

**(2+1)**

### **Theory**

**UNIT I :** Definition of seed and its quality, new seed policies; DUS test, scope of vegetable seed industry in India. Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behaviour, seed development and maturation ; methods of hybrid seed production.

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

**UNIT 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 :** Agro-techniques for seed production in solanaceous vegetables, cucurbits, leguminous vegetables, colecrops, bulb crops, leafy vegetables, okra, vegetatively propagated vegetables.

### **Practical**

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

### **Suggested Readings**

- Agrawal PK & Dadlani M. (Eds.) 1992. *Techniques in Seed Science and Technology*. South Asian Publ.
- Agrawal RL. (Ed.). 1997. *Seed Technology*. Oxford & IBH.
- Bendell PE. (Ed.) 1998. *Seed Science and Technology: Indian Forestry Species*. Allied Publ.
- Fageria MS, Arya PS & Choudhary AK. 2000. *Vegetable Crops: Breeding and Seed Production*. Vol. I. Kalyani.
- George RAT. 1999. *Vegetable Seed Production*. 2<sup>nd</sup> Ed. CABI.
- Kumar JC & Dhaliwal MS. 1990. *Techniques of Developing Hybrids in Vegetable Crops*. Agro Botanical Publ.
- More TA, Kale PB & Khule BW. 1996. *Vegetable Seed Production Technology*. Maharashtra State Seed Corp.
- Rajan S & Baby L Markose. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency.
- Singh NP, Singh DK, Singh YK & Kumar V. 2006. *Vegetable Seed Production Technology*. International Book Distributing Co.
- Singh SP. 2001. *Seed Production of Commercial Vegetables*. Agrotech Publ. Academy.

## **HOR PG 515 PRODUCTION TECHNOLOGY OF UNDEREXPLOITED VEGETABLE CROPS (2+1)**

### **Theory**

Introduction, botany and taxonomy, climatic and soil requirements, commercial Varieties/ hybrids,

sowing/ planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed production of:

**UNIT I :** Asparagus, artichoke, leek, Brussels's sprout, Chinese cabbage, broccoli, kale and artichoke.

**UNIT II :** Amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathu (chenopods) and chekurmanis.

**UNIT III :** Elephant foot yam, lima bean, winged bean, vegetable pigeon pea, jack bean and sword bean.

**UNIT IV :** Sweet gourd, spine gourd, pointed gourd, Chayote, Meetha Karela, 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.

### **Suggested Readings**

- Bhat KL. 2001. Minor Vegetables - Untapped Potential. Kalyani.
- Indira P & Peter KV. 1984. Unexploited Tropical Vegetables. Kerala Agricultural University, Kerala.
- Peter KV. (Ed.). 2007-08. Underutilized and Underexploited Horticultural Crops. Vols. I-IV. New India Publ. Agency.
- Rubatzky VE & Yamaguchi M. (Eds.). 1997. World Vegetables: Principles, Production and Nutritive Values. Chapman & Hall
- Srivastava U, Mahajan RK, Gangopadyay KK, Singh M & Dhillon
- BS. 2001. Minimal Descriptors of Agri-Horticultural Crops. Part-II: Vegetable Crops. NBPGR, New Delhi.

## **PLANTATION, SPICES, MEDICINAL & AROMATIC CROPS**

**HOR PG 531 PRODUCTION OF PLANTATION CROPS**

**(2+1)**

### **Theory**

Role of plantation crops in national economy, export potential, IPR issues, clean development mechanism, classification and varietal wealth. Plant multiplication including *in vitro* multiplication, systems of cultivation, multitier cropping, photosynthetic efficiencies of crops at different tiers, rainfall, humidity, temperature, light and soil pH on crop growth and productivity, high density planting, nutritional requirements, physiological disorders, role of growth regulators and macro and micronutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management, training and pruning, crop regulation, maturity indices, harvesting. Cost benefit analysis, organic farming, management of drought, precision farming.

### **Crops**

**UNIT I:** Coffee, tea, cocoa

**UNIT II:** Coconut, arecanut, palmyrah palm, oil palm

**UNIT III:** Cashew, rubber

**UNIT IV:** Betel vine and wattle

### **Practical**

Description of botanical and varietal features, selection of mother palms and seedlings in coconut and arecanut, soil test crop response studies and manuring practices, pruning and training, maturity standards, harvesting, Project preparation for establishing plantations, visit to plantations, plantation research institutes/centres

### **Suggested Readings**

- Anonymous, 1985. *Rubber and its Cultivation*. The Rubber Board of India
- Chopra VL & Peter KV. 2005. *Handbook of Industrial Crops*. Panima.
- Harler CR. 1963. *The Culture and Marketing of Tea*. Oxford Univ. Press.
- Kumar N. 2014. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Oxford and IBH Publishing Co. Pvt. Ltd.
- Kurian A & Peter K.V. 2007. *Commercial Crops Technology*. New India Publ. Agency.
- Nair MK, Bhaskara Rao EVV, Nambiar KKN & Nambiar MC. 1979. *Cashew*. CPCRI, Kasaragod.
- Peter KV. 2002. *Plantation Crops*. National Book Trust.
- Pradeep Kumar T, Suma B, Jyothibhaskar & Satheesan KN. 2008. *Management of Horticultural Crops*. Part I, II. New India Publ. Agency.
- Rai PS & Vidyachandram B. 1981. *Review of Work Done on Cashew*. UAS, Research Series No.6, Bangalore.
- Ranganathan V. 1979. *Hand Book of Tea Cultivation*. UPASI, Tea Res. Stn. Cinchona

- Shanmugavelu KG, Kumar N & Peter KV. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.
- Srivastava HC, Vatsaya B & Menon KKG. 1986. *Plantation Crops– Opportunities and Constraints*. Oxford & IBH.
- Thampan P.K. 1981. *Hand Book of Coconut Palm*. Oxford & IBH.

## **HOR PG 532 PRODUCTION TECHNOLOGY OF SPICE CROPS**

(2+1)

### **Theory**

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

**UNIT I :** Blackpepper, cardamom (large and small), clove, nutmeg

**UNIT II :** Turmeric, ginger, garlic, cinnamon

**UNIT III :** Allspice, coriander, cumin, fennel, fenugreek

**UNIT IV :** Ajowain, dill, celery, tamarind, garcinia, vanilla

### **Practical**

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

### **Suggested Readings**

- Agarwal S, Sastry EVD & Sharma RK. 2001. *Seed Spices: Production, Quality, Export*. Pointer Publ.
- Arya PS. 2003. *Spice Crops of India*. Kalyani.
- Bose TK, Mitra SK, Farooqi SK & Sadhu MK (Eds.). 1999. *Tropical Horticulture*. Vol.I. Naya Prokash.
- Chadha KL & Rethinam P. (Eds.). 1993. *Advances in Horticulture*. Vols. IX-X. *Plantation Crops and Spices*. Malhotra Publ. House.

- Gupta S. (Ed.). *Hand Book of Spices and Packaging with Formulae*. Engineers India Research Institute, New Delhi.
- Kumar N., 2014. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Oxford & IBH Publishing Co. Pvt. Ltd.
- Nybe EV, Miniraj N & Peter KV. 2007. *Spices*. New India Publ. Agency. Parthasarthy VA, Kandiannan V & Srinivasan V. 2008. *Organic Spices*. New India Publ. Agency.
- Peter KV. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ.Co. UK and CRC USA
- Pruthi JS. (Ed.). 1998. *Spices and Condiments*. National Book Trust
- Pruthi JS.2001. *Minor Spices and Condiments- Crop Management and Post Harvest Technology*. ICAR.
- Purselove JW, Brown EG, Green CL &Robbins SRJ. (Eds.). 1981. *Spices*. Vols. I, II. Longman.
- Shanmugavelu KG, Kumar N & Peter KV. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.
- Thamburaj S & Singh N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*. ICAR.
- Tiwari RS & Agarwal A. 2004. *Production Technology of Spices*. International Book Distr. Co.
- VarmudyV.2001. *Marketing of Spices*. Daya Publ. House.

**HOR PG533 PRODUCTION TECHNOLOGY FOR MEDICINAL AND AROMATIC CROPS (2+1)**

**Theory**

**UNIT I**

Herbal and aromatic industry, WTO scenario, Export and import status, Indian system of medicine, Indigenous Traditional Knowledge, IPR issues, Classification of medicinal crops, Indian perfumery industry, Role of institutions and NGO's in production, GAP in medicinal crop production.

**UNIT II**

Production technology and post harvest handling and processing for Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Sarpagandha, *Dioscorea* sp., *Aloe vera*, *Phyllanthus amarus*, *Andrographis paniculata*.

**UNIT III**

Production technology for Medicinal solanum, Isabgol, Poppy, Safed musli, *Stevia rebaudiana*, *Mucuna pruriens*, *Ocimum* sp.

## **UNIT IV**

Production technology, postharvest handling and processing for palmarosa, lemongrass, citronella, vetiver, geranium, artemisia, mentha, ocimum, eucalyptus, rosemary, thyme, patchouli, lavender, marjoram, oreganum.

### **Practical**

Botanical description, Propagation techniques, Maturity standards, Digital documentation, Extraction of secondary metabolites, Project preparation for commercially important medicinal crops, Visit to medicinal crop fields, Visit to herbal extraction units.

Extraction of Essential oils, Project preparation for commercially important Aromatic crops, Visit to distillation and value addition units–Visit to CIMAP.

### **Suggested Readings**

- Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Aromatic Plants*. RRL, CSIR, Jammu.
- Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.
- Farooqi AA & Sriram AH. 2000. *Cultivation Practices for Medicinal and Aromatic Crops*. Orient Longman Publ.
- Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops*. Natural Remedies Pvt. Ltd. Hota D. 2007. *Bio Active Medicinal Plants*. Gene Tech Books.
- Jain SK. 2000. *Medicinal Plants*. National Book Trust.
- Khan IA & Khanum A. *Role of Bio Technology in Medicinal and Aromatic Plants*. Vol. IX. Vkaaz Publ.
- Kurian A & Asha Sankar M. 2007. *Medicinal Plants*. Horticulture Science Series, New India Publ. Agency.
- Panda H. 2002. *Medicinal Plants Cultivation and their Uses*. Asia Pacific Business Press.
- Prajapati SS, Paero H, Sharma AK & Kumar T. 2006. *A Handbook of Medicinal Plants*. Agro Bios.
- Ramawat KG & Merillon JM. 2003. *BioTechnology-Secondary Metabolites*. Oxford & IBH.
- Skaria P Baby, Samuel Mathew, Gracy Mathew, Ancy Joseph, Ragina
- Joseph. 2007. *Aromatic Plants*. New India Publ. Agency.

## **HOR PG 534 BREEDING OF PLANTATION CROPS AND SPICES**

**(2+1)**

### **Theory**

Species and cultivars, cytogenetics, survey, collection, conservation and evaluation, blossom biology, breeding objectives, approaches for crop improvement, introduction, selection,

hybridization, mutation breeding, polyploid breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, molecular aided breeding and biotechnological approaches, marker-assisted selection, bioinformatics, IPR issues, achievements and future thrusts.

## **Crops**

**UNIT I:** Coffee, tea, cocoa, cashew, rubber

**UNIT II:** Coconut, arecanut, palmyrah palm, oil palm

**UNIT III:** Black pepper, cardamom (large and small), ginger, turmeric, nutmeg, cinnamon, clove

**UNIT IV:** Allspice, fenugreek, coriander, fennel, celery, ajowain

## **Practical**

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

## **Suggested Reading:-**

- Auxilia J. and Shabha N. (2017). *Breeding of Fruits and Plantation Crops*. www.agrimoon.com
- Anonymous 1985. *Rubber and its Cultivation*. The Rubber Board of India. Chadha KL & Rethinam P. (Eds.). 1993. *Advances in Horticulture*. Vol. IX. *Plantation Crops and Spices*. Part-I. Malhotra Publ. House.
- Chadha KL, Ravindran PN & Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.
- Chadha KL. 1998. *Advances in Horticulture*. Vol. IX. *Plantation and Spices Crops*. Malhotra Publishing House, New Delhi.
- Chopra VL & Peter KV. *Handbook of Industrial Crops*. Haworth Press.
- Panama International Publishers, New Delhi (Indian Ed.). Damodaran VK, Vilaschandran T & Valsalakumari PK. 1979. *Research on Cashew in India*. KAU, Trichur.
- Ferwerden FP & Wit F. (Ed.). 1969. *Outlines of Perennial Crop Breeding in the Tropics*. H. Veenman & Zonen.
- Harver AE. 1962. *Modern Coffee Production*. Leonard Hoff.
- Raj PS & Vidyachandra B. 1981. *Review of Work Done on Cashew*. UAS Research Series No.6, Bangalore.
- Thampan PK 1981. *Hand Book of Coconut Palm*. Oxford & IBH.

## **HOR PG 535 BREEDING OF MEDICINAL AND AROMATIC CROPS (2+1)**

### **Theory**

#### **UNIT I**

Plant bio-diversity, conservation of germplasm, IPR issues, Major objectives of breeding of Medicinal and Aromatic Crops, Scope for introduction; cytogenetic background of important Medicinal and Aromatic Crops; Scope for improvement of Medicinal and Aromatic Crops through selection, intra and interspecific hybridization, induced autotetraploidy, mutation breeding and biotechnological approaches.

#### **UNIT II**

Breeding for yield and quality improvement in medicinal plants, Breeding for high herbage yield, essential oil and quality components, secondary metabolites in medicinal and aromatic crops; Genetics of active principles and assay techniques useful in evaluation of breeder's material. Breeding problems in seed and vegetatively propagated medicinal and aromatic crops.

#### **UNIT III**

Achievements and prospects in breeding of medicinal crops, viz. *Cassia angustifolia*, *Catharanthus roseus*, *Gloriosa superba*, *Coleus forskohlii*, *Stevia*, *Withania somnifera*, *Papaver somniferum*, *Plantago ovata*, *Dioscorea* sp.

#### **UNIT IV**

Prospects in breeding of medicinal crops, viz. *Chlorophytum* sp, *Rauwolfia serpentina*, *Aloe vera*, *Ocimum* sp, *Phyllanthus amarus*, *Solanum* sp. Geranium, vetiver, Lemon grass, Palmarosa, citronella, Rosemary, Patchouli, Eucalyptus, Artemisia and Mint

### **Practical**

Description of Botanical features, Cataloguing of cultivars, varieties and species in medicinal and aromatic crops, Floral Biology, Selfing and crossing, Evaluation of hybrid progenies, Induction of economic mutants, High alkaloid and high essential oil mutants, evolution of mutants through physical and chemical mutagens, Introduction of polyploidy, Screening of plants for biotic and abiotic stress and environmental pollution, *in-vitro* breeding in medicinal and aromatic crops.

### **Suggested Readings**

- Atal CK & Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.
- Chadha KL & Gupta R. 1995. *Advances in Horticulture*. Vol.XI. Malhotra Publ.House.
- Farooqi AA, Khan MM & Vasundhara M. 2001. *Production Technology of*

*Medicinal and Aromatic Crops*. Natural Remedies Pvt. Ltd. Jain SK. 2000.  
*Medicinal Plants*. National Book Trust.

- Julia F & Charters MC. 1997. *Major Medicinal Plants–Botany, Cultures and Uses*. Thomas Publ.
- Kurian A & Asha Sankar, M. 2007. *Medicinal Plants*. Horticulture Science Series, New India Publ. Agency.
- Prajapati ND, Paero Hit SS, Sharma AK, Kumar T. 2006. *A Hand book of Medicinal Plants*. Agro Bios (India).
- Skaria P Babu. 2007. *Aromatic Plants*. New India Publ. Agency.
- Thakur RS, Pauri HS & Hussain A.1989. *Major Medicinal Plants of India* CSIR.

## **COMMON COMPULSORY MAJOR COURSES FOR ALL STUDENTS**

### **HOR PG 541 POST HARVEST TECHNOLOGY FOR HORTICULTURE CROPS (2+1)**

#### **Theory**

##### **UNIT I**

Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration,

##### **UNIT II**

Ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling. Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products.

##### **UNIT III**

Methods of storage- ventilated, refrigerated, MAS, CA storage, physical injuries and disorders. Packing methods and transport, principles and methods of preservation.

##### **UNIT IV**

Food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies. Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

#### **Practical**

Analyzing maturity stages of commercially important horticultural crops, improved packing and storage of important horticultural commodities, 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, estimation of quality characteristics in stored fruits and vegetables, cold chain management- visit to storage units and processing units, project preparation, evaluation of processed horticultural products.

#### **Suggested Readings**

- Bhutani RC. 2003. *Fruit and Vegetable Preservation*. Biotech Books.
- Chadha KL & Pareek OP. (Eds.). 1996 *Advances in Horticulture*. Vol. IV. Malhotra Publ. House.
- Haid NF & Salunkhe SK. 1997. *Post Harvest Physiology and Handling of Fruits and Vegetables*. Grenada Publ.
- Mitra SK. 1997. *Post Harvest Physiology and Storage Sub-tropical Fruits*. CABI.
- Ranganna S. 1997. *Hand Book of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw-Hill.

- Sudheer KP & Indira V. 2007. *Post Harvest Technology of Horticultural Crops*. New India Publ. Agency.
- Willis R, McGlassenWB, Graham D & Joyce D. 1998. *Post Harvest: An Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals*. CABI.

## **HOR PG542 GROWTH REGULATION OF HORTICULTURAL CROPS**

(2+1)

### **Theory**

#### **UNIT I**

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, the photoperiodism.

#### **UNIT II**

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.

#### **UNIT III**

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.

#### **UNIT IV**

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**

Understanding dormancy mechanisms in seeds, tubers and bulbs and stratification of seeds, tubers and bulbs, visit to arid, subtropical and temperate horticultural zones to identify growth and development patterns, techniques of growth analysis, evaluation of photosynthetic efficiency under different environments, study of growth regulator functions, hormone assays, understanding ripening phenomenon in fruits and vegetables, study of impact of physical manipulations on growth and development, study of chemical manipulations on growth and development, understanding stress impact on growth and development.

### **Suggested Readings**

- Buchanan B, Gruissem W & Jones R. 2002. *Biochemistry & Molecular Biology of*

*Plants*. John Wiley & Sons.

- Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. Wiley.
- Fosket DE. 1994. *Plant Growth and Development: a Molecular Approach*. Academic Press.
- Leopold AC & Kriedermann PE. 1985. *Plant Growth and Development*. 3<sup>rd</sup> Ed. Mc Graw-Hill.
- Peter KV. 2008. (Ed.) *Basics of Horticulture*. New India Publ. Agency. Roberts J, Downs S & Parker P. 2002. Plant Growth Development. In: *Plants* (I. Ridge, Ed.), pp. 221-274, Oxford University Press. Salisbury FB & Ross CW. 1992. *Plant Physiology*. 4<sup>th</sup> Ed. Wadsworth Publ.

## **HOR PG 543 PROTECTED CULTIVATION OF HORTICULTURE CROPS (2+1)**

### **Theory**

#### **UNIT I**

Greenhouse –World scenario, Indian situation: present and future, Different agro-climatic zones in India, Environmental factors and their effects on plant growth. Basics of greenhouse design, different types of structures–glasshouse, shadenet, polytunnels

#### **UNIT II**

Design and development of greenhouse structures. Sanitization of green house, Interaction of light, temperature, humidity, CO<sub>2</sub>, water on crop regulation- Green house heating, cooling, ventilation and shading.

#### **UNIT III**

Types of ventilation-Forced cooling techniques-glazingmaterials -Micro irrigation and Fertigation. Management of pest and diseases – IPM.

#### **UNIT IV**

Automated greenhouses, microcontrollers, waste water recycling, high density farming under green house -vertical farming, Soilless culture- hydroponic, aeroponic, NFT etc

### **Practical**

Designs of greenhouse, low cost polytunnels, nethouse – Regulation of light, temperature, humidity in greenhouses, media, greenhouse cooling systems, ventilation systems, soilless culture, fertigation systems, special management practices, project preparation for greenhouses, visit to greenhouses.

### **Suggested Readings**

- Aldrich RA & Bartok JW. 1994. *Green House Engineering*. NRAES, Riley, Robb Hall, Cornell

University, Ithaca, New York.

- Bhattacharjee BS. 1959. *Rose Growing in Tropics*. Thackarspink & Co.
- Laurie A, Kiplingr DD & Nelson KS.1968. *Commercial Flower Forcing*. McGraw-Hill.
- MearsDR, KimMK &Roberts WJ. 1971. *Structural Analysis at an Experimental Cable-supported Air Inflated Green Houses*. Trans. ASAE.
- Pant V Nelson. 1991. *Green House Operation and Management*. Bali Publ.
- Pradeep kumar T, Suma B, Jyothibhaskar & Satheesan KN. 2007. *Management of Horticultural Crops*. Parts I,II. New India Publ. Agency.

## **HOR PG 544 BIOTECHNOLOGY FOR CROP IMPROVEMENT**

(2+1)

### **Theory**

#### **UNIT I**

Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding. Tissue culture- History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.

#### **UNIT II**

Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.), mapping populations (F2s, back crosses, RILs, NILs and DH).

#### **UNIT III**

Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding. Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression, Generation of EDVs.

#### **UNIT IV**

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer. Production of transgenic plants in various horticultural crops and Commercial releases. MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property

rights. Bioinformatics & Bioinformatics tools. Nanotechnology and its applications in crop improvement programmes.

### **Practical**

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants ; observations on the contaminants occurring in media – interpretations - Inoculation of explants; Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial micropropagation unit. Transformation using Agrobacterium strains, GUS assay in transformed cells / tissues. DNA isolation, DNA purity and quantification tests, gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship, construction of genetic linkage maps using computer software.

### **Suggested Readings**

- Chopra VL & Nasim A. 1990. Genetic Engineering and Biotechnology: Concepts, Methods and Applications. Oxford & IBH.
- Gupta PK. 1997. Elements of Biotechnology. Rastogi Publ.
- Hackett PB, Fuchs JA & Messing JW. 1988. An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation. 2nd Ed. Benjamin Publ. Co.
- Sambrook J & Russel D. 2001. Molecular Cloning - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.
- Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani.

## **HOR PG 545: ORGANIC HORTICULTURE AND GAP**

[2+1]

### **Objective**

To develop understanding of organic horticulture production system including GAP.

### **Theory**

#### **UNIT I**

Organic horticulture – definition, synonyms and misnomers, principles, methods, merits and demerits. Organic farming systems, components of organic horticultural systems, different organic inputs, their role in organic horticulture, role of biofertilizers, biodynamics and the recent developments.

#### **UNIT II**

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 III**

Genesis of GAP – definition/description, Principles and management, components listed by FAO, framework, HACCP exercise, certification of organic products and systems, agencies involved at national and international levels, standards evolved by different agencies.

### **UNIT IV**

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, framework for GAP, case studies, HACCP analysis, residue analysis in organic products, documentation for certification, visit to fields cultivated under organic practices

### **Suggested Readings**

- Claude A, Vandana S, Sultan I, Vijaya L, Korah M & Bernard D. 2000.
- *The Organic Farming Reader*. Other Indian Press, Goa.
- Gaur AC, Neblakantan S & Dargan KS. 1984 *Organic Manures*. ICAR.
- Lampkin N & Ipswich. 1990. *Organic Farming*. Farming Press. London.
- Lampkin NH & Padel S. 1992. *The Economics of Organic Farming – An International Perspective*. CABI.
- Palaniappan & Annadurai. 2008. *Organic Farming- Theory and Practise*. Scientific Publ.
- Peter KV. 2008. (Ed.). *Basics of Horticulture*. New India Publ. Agency. New Delhi.
- Rao S. 1977. *Soil Microorganism and Plant Growth*. Oxford & IBH.

## **HOR PG 546 EXPERIMENTAL DESIGNS**

**(2+1)**

### **Theory**

#### **UNIT I**

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

## **UNIT II**

Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

## **UNIT III**

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

## **UNIT IV**

Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ Lattice design, alpha design - concepts, randomisation procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

## **Practical**

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Analysis of resolvable designs; Fitting of response surfaces.

## **Suggested Readings**

- Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
- Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.
- Federer WT. 1985. Experimental Designs. MacMillan.
- Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
- Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.
- Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice.
- Design Resources Server: [www.iasri.res.in/design](http://www.iasri.res.in/design).

## **COMPULSORY SUPPORTIVE COURSES FOR ALL STUDENTS**

### **CourseContents**

#### **HOR PG 571 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE**

**(1+0)**

##### **Theory**

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPS and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio-diversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research Collaboration, Agreement, License Agreement.

##### **Suggested Readings**

- Erbisch FH & Maredia K. 1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
- Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
- *Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC & Aesthetic Technologies.
- Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.
- Rothschild M & Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
- Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.
- *The Indian Acts-Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.*

#### **HORT PG 572 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)**

##### **Practical**

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccumets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of

solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollenviability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy.

### **Suggested Readings**

- Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
- GabbMH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

## **HOR PG 573 LIBRARY AND INFORMATION SERVICES**

**(0+1)**

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

### **Practical**

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information-Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including searching in e and its resources; e-resources access methods.

## **HOR PG 574 TECHNICAL WRITING AND COMMUNICATIONS SKILLS**

**(1+0)**

To equip the students/ scholars with skills to write dissertations, research papers, etc.

To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

### **Practical**

**Technical Writing-** Various for most scientific writings - theses, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering

of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article.

**Communication Skills-** Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

### **Suggested Readings**

- *Chicago Manual of Style*. 14<sup>th</sup> Ed. 1996. Prentice Hall of India.
- *Collins' Cobuild English Dictionary*. 1995. Harper Collins.
- Gordon HM & Walter JA. 1970. *Technical Writing*. 3<sup>rd</sup> Ed. Holt, Rinehart & Winston.
- Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6<sup>th</sup> Ed. Oxford University Press.
- James HS. 1994. *Handbook for Technical Writing*. NTC Business Books. Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5<sup>th</sup> Ed. Affiliated East-West Press.
- Mohan K. 2005. *Speaking English Effectively*. MacMillan India. Richard WS. 1969. *Technical Writing*. Barnes & Noble.
- Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*. Abhishek. Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2<sup>nd</sup> Ed. Prentice Hall of India.
- Wren PC & Martin H. 2006. *High School English Grammar and Composition*. S. Chand & Co.

## **HORT PG 575      AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES      (1+0)**

### **Theory**

#### **UNIT I**

History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

#### **UNIT II**

Research ethics: research integrity, research safety in laboratories, welfare of animals

used in research, computer ethics, standards and problems in research ethics.

### **UNIT III**

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group– Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

#### **Suggested Readings**

- Bhalla GS & Singh G. 2001. *Indian Agriculture- Four Decades of Development*. Sage Publ.
- Punia MS. *Manual on International Research and Research Ethics*. CCS, Haryana Agricultural University, Hisar.
- Rao BSV. 2007. *Rural Development Strategies and Role of Institutions- Issues, Innovations and Initiatives*. Mittal Publ.
- Singh K. 1998. *Rural Development-Principles, Policies and Management*. Sage Publ.

### **HOR PG 576 DISASTER MANAGEMENT**

**(1+0)**

#### **Theory**

### **UNIT I**

Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion

### **UNIT II**

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial waste water pollution, road accidents, rail accidents, air accidents, sea accidents.

### **UNIT III**

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management frame work; financial arrangements;

### **UNIT IV**

Role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

### **Suggested Readings**

- Gupta HK. 2003. *Disaster Management*. Indian National Science Academy. Orient Blackswan.
- Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: A Handbook of Disaster Management*. Routledge.
- Sharma VK. 2001. *Disaster Management*. National Centre for Disaster Management, India.

### **HOR PG 590 MASTER'S SEMINAR**

**(1+0)**

The students will deliver a one credit compulsory seminar related to his or her major course.

### **HOR PG 591 MASTER'S RESEARCH**

**(20)**

The Master's student will have to submit synopsis of the research work to be done in the first semester and it will be approved by Departmental Research Committee. The student will have to submit thesis maximum at the end of fourth semester.

### **HOR PG 592 COMPREHENSIVE EXAMINATION**

Comprehensive exam is compulsory for all students. Exam will held at the begning of fourth semester. Qualifying marks is 60%.

## Minor Courses

### Plant Physiology [561-563]

**HOR PG 561**

**PRINCIPLES OF PLANT PHYSIOLOGY**

**2+1**

#### **Objective**

To acquaint the students with the basic concepts of plant physiology and their application in agriculture.  
Theory

#### **UNIT I**

Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells. Mechanism of water uptake by roots-transport in roots, aquaporins, movement of water in plants – Mycorrhizal association on water uptake. Water loss from plants - Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration transpiration –Driving force for transpiration, plant factors influencing transpiration rate.

#### **UNIT II**

Stomata structure and function – mechanism of stomatal movement, antitranspirants. Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

#### **UNIT III**

The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants. Uptake of mineral elements in plants –Mechanisms of uptake- translocation of minerals in plants. Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition. Photosynthesis and its importance in bio productivity. Photochemical process, photochemical reactions, CO<sub>2</sub> reduction in Calvin cycle, supplementary pathway of C fixation in C<sub>4</sub> and CAM plants and its significance.

#### **UNIT IV**

Photorespiration and its relevance. Photosynthesis as a diffusive process effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall). Translocation of photosynthates and its importance in sink growth.

#### **UNIT V**

Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance. Nitrogen metabolism: Inorganic nitrogen species (N<sub>2</sub>, NO<sub>3</sub> and NH<sub>3</sub>) and their reduction to aminoacids, protein synthesis and nucleic acids. Lipid metabolism- Storage, protective and structural lipids. Biosynthesis of fattyacids, diacyl and triacyl glycerol, fatty acids of storage lipids. Secondary metabolites and their significance in plant defence mechanism.

#### **Practical**

Measurement of soil water status: Theory and principle of pressure plate apparatus, neutron probe, Measurement of plant water status: Relative water content, water saturation deficits Chardakov's test.

Theory and principle of pressure bomb, psychrometer and osmometer, Measurement of transpiration rate. Measurement of vapour pressure deficits, theory and principle of porometry, diffusion prometer and Steady state porometer, Stomatal physiology, influence of ABA on stomatal closing. Mineral nutrients: Demonstration of energy requirement for ion uptake. Deficiency symptoms of nutrients, Radiant energy measurements, separation and quantification of chlorophylls, O<sub>2</sub> evolution during photosynthesis, Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration, Respiration rates, Estimation of reducing sugars, starch. Estimation of NO<sub>3</sub>, free aminoacids in the xylem exudates, quantification of soluble proteins. Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene. Demonstration of photoperiodic response of plants in terms of flowering.

### **Suggested Readings**

- Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.
- Salisbury FB & Ross C. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.
- Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

## **HOR PG 562 PLANT DEVELOPMENTAL BIOLOGY PHYSIOLOGICAL AND MOLECULAR BASIS**

**3+0**

### **Objective**

To explain about basic physiological and molecular processes concerning various facets of growth and development of plants.

### **Theory**

#### **UNIT I**

Plant Biodiversity, Concept of evolution in plants. General Aspects – Novel features of plant growth and development; Concept of plasticity in plant development; Analysing plant growth. Seed Germination and Seedling Growth – Mobilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth. Regeneration and totipotency; Organ differentiation and development;

#### **UNIT II**

Shoot, Leaf and Root Development – Organization of shoot apical meristem (SAM); Control of cell division and cell to cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of root apical meristem (RAM); Root hair and trichome development; Cell fate and lineages.

#### **UNIT III**

Floral Induction and Development – Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation; Sex determination.

#### **UNIT IV**

Seed Development and Dormancy – Embryo and endosperm development; Cell lineages during late embryo development; Molecular and genetic determinants; Seed maturation and dormancy. Senescence and Programmed Cell Death (PCD) – Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

## UNIT V

Light Control of Plant Development – Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants

### Suggested Readings

- Kabita Datta 2007. *Plant Physiology*. Mittal Publ.
- Srivastava L.M. 2002. *Plant Growth and Development: Hormones and Environment*. Academic Press.
- Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.
- Wareing PF & Phillips IDJ. 1981. *Growth and Differentiation in Plants*. 3rd Ed. Pergamon Press.
- Wilkins MB. 1969. *Physiology of Plant Growth and Development*. Tata McGraw-Hill.

## HOR PG 563 PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES 2+1

### Objective

To apprise the students regarding abiotic stress to plant and its molecular basis.

### Theory

#### UNIT I

Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, Interactions between biotic and abiotic stresses.

#### UNIT II

Drought-characteristic features, Water potential in the soil-Plant air continuum. Development of water deficits, energy balance concept. Transpiration and its regulation – stomatal functions. Physiological processes affected by drought. Drought resistance mechanisms: Escape Dehydration postponement (Drought avoidance), Dehydration tolerance and characteristics of resurrection plants. Osmotic adjustment, Osmoprotectants, Stress proteins. Water use efficiency as a drought resistant trait.

#### UNIT III

Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products. Stress and hormones- ABA as a signaling molecule- Cytokinin as a negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD catalase etc.).

#### UNIT IV

High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSP's. Chilling stress: Effects on physiological processes. Crucial role of membrane lipids.

#### UNIT V

Salinity: Species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, tolerance mechanisms. Salt tolerance in – Glycophytes and halophytes, Breeding for salt resistance. Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of Phytochelatins (heavy metal binding proteins).

### **Practical**

Measurement of water status of plants, determination of osmotic potential by vapour pressure and freezing point depression, Determination of soil water potential and content by psychrometry and other systems. Stress imposition and quantification, Stress –stomatal conductance. Canopy temperature as a reflection of transpiration and root activity, Water use – efficiency, Determination at whole plant and single leaf level, Root- shoot signals-ABA and cytokinin effect on stomatal behavior, Heat tolerance and membrane integrity. Sullivans heat tolerance test, chilling tolerance- Galactolipase and free fatty acid levels as biochemical markers for chilling damage, Cold induced inactivation of O<sub>2</sub> evolution of chloroplasts- as a screening technique for chilling tolerance.

### **Suggested Readings**

- Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.
- Salisbury FB & Ross C. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.
- Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

## Plant Protection [564-566]

### **HOR PG 564 PRINCIPLES OF PLANT PATHOLOGY**

**3+0**

#### **Objective**

To introduce the subject of Plant Pathology, its concepts and principles.

#### **Theory**

#### **UNIT I**

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

#### **UNIT II**

Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.

#### **UNIT III**

Host parasite interaction, recognition concept and infection, symptomatology, disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

#### **UNIT IV**

Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

#### **Suggested Readings**

- Agrios GN. 2005. *Plant Pathology*. 5th Ed. Academic Press, New York.
- Heitefuss R & Williams PH. 1976. *Physiological Plant Pathology*. Springer Verlag, Berlin, New York.
- Mehrotra RS & Aggarwal A. 2003. *Plant Pathology*. 2nd Ed. Oxford & IBH, New Delhi.
- Singh RS. 2002. *Introduction to Principles of Plant Pathology*. Oxford & IBH, New Delhi.
- Singh DP & Singh A. 2007. *Disease and Insect Resistance in Plants*. Oxford & IBH, New Delhi.
- Upadhyay RK & Mukherjee KG. 1997. *Toxins in Plant Disease Development and Evolving Biotechnology*. Oxford & IBH, New Delhi.

### **HOR PG 565**

### **PRINCIPLES OF PLANT DISEASE MANAGEMENT**

**2+1**

#### **Objectives**

To acquaint with different strategies for management of plant diseases.

#### **Theory**

#### **UNIT I**

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanical methods of plant disease control, integrated control measures of plant diseases.

## **UNIT II**

History of fungicides, bactericides, concepts of pathogen immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals.

## **UNIT III**

Foliage, seed and soil application of chemicals, role of stickers, spreaders and other adjuvants, health vis-a-vis environmental hazards, residual effects and safety measures.

## **UNIT IV**

Disease resistance and molecular approach for disease management.

## **Practical**

*In vitro* and *in vivo* evaluation of chemicals against plant pathogens; ED and MIC values, study of structural details of sprayers and dusters.

## **Suggested Readings**

- Fry WE. 1982. *Principles of Plant Disease Management*. Academic Press, New York.
- Hewitt HG. 1998. *Fungicides in Crop Protection*. CABI, Wallington.
- Marsh RW. 1972. *Systemic Fungicides*. Longman, New York.
- Nene YL & Thapliyal PN. 1993. *Fungicides in Plant Disease Control*. Oxford & IBH, New Delhi.
- Palti J. 1981. *Cultural Practices and Infectious Crop Diseases*. Springer- Verlag, New York.
- Vyas SC. 1993 *Handbook of Systemic Fungicides*. Vols. I-III. Tata McGraw Hill, New Delhi.

## **HOR PG 566 PRINCIPLES OF INTEGRATED PEST MANAGEMENT AND PLANT RESISTANCE TO INSECTS**

**2+1**

## **Theory**

### **UNIT I**

Concept and philosophy, ecological principles, economic threshold concept, and economic consideration.

### **UNIT II**

Tools of pest management and their integration- legislative, cultural, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest population estimation methods; crop loss assessment pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

### **UNIT III**

Importance of host plant resistance, principles, classification, components, types and mechanisms of resistance. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

### **UNIT IV**

Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance - acquired and induced systemic resistance. Factors affecting plant resistance including biotypes and measures to combat them. Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world. Role of biotechnology in plant resistance to insects.

### **Practical**

Characterization of agro-ecosystems; Computation of EIL and ETL; crop modeling; designing and implementing IPM system. Screening techniques for measuring resistance; measurement of plant characters and working out their correlations with plant resistance; testing of resistance in important crops; bioassay of plant extracts of susceptible/resistant varieties, demonstration of antibiosis, tolerance and antixenosis.

### **Suggested Readings**

- Dhaliwal GS & Arora R. 2003. *Integrated Pest Management – Concepts and Approaches*. Kalyani Publ., New Delhi.
- Dhaliwal GS, Singh R & Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publ., New Delhi.
- Flint MC & Bosch RV. 1981. *Introduction to Integrated Pest Management*. 1st Ed., Springer, New York.
- Horowitz AR & Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.
- Ignacimuthu SS & Jayaraj S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.
- Metcalf RL & Luckman WH. 1982. *Introduction of Insect Pest Management*. John Wiley & Sons, New York.
- Pedigo RL. 2002. *Entomology and Pest Management*. 4th Ed. Prentice Hall, New Delhi.
- Norris RF, Caswell-Chen EP & Kogan M. 2002. *Concepts in Integrated Pest Management*. Prentice Hall, New Delhi.
- Subramanyam B & Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products*. Marcel Dekker, New York.
- Dhaliwal GS & Singh R. (Eds). 2004. *Host Plant Resistance to Insects - Concepts and Applications*. Panima Publ., New Delhi.
- Maxwell FG & Jennings PR. (Eds). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons, New York.
- Painter RH. 1951. *Insect Resistance in Crop Plants*. MacMillan, London.
- Panda N & Khush GS. 1995. *Plant Resistance to Insects*. CABI, London.
- Smith CM. 2005. *Plant Resistance to Arthropods – Molecular and Conventional Approaches*. Springer, Berlin.

## **Genetics and Plant Breeding [567-569]**

### **HOR PG 567: PRINCIPLES OF GENETICS**

**(2+1)**

#### **Theory**

**UNIT I:** Beginning of genetics; Cell structure and cell division; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance. Multiple alleles, Gene interactions. Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

**UNIT II:** Population - Mendelian population – Random mating population -Frequencies of genes and Genotypes-Causes of change: Hardy-Weinberg equilibrium. Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis.

**UNIT III:** Genetic fine structure analysis, Allelic complementation, split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters. Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression. Gene regulation in eukaryotes, RNA editing.

**UNIT IV:** Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (mi RNAs). Genomics and proteomics; Functional and pharmacogenomics; Metagenomics. Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics.

#### **Practical**

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification -Electrophoresis – basic principles and running of amplified DNA - Extraction of proteins and isozymes – use of Agrobacterium mediated method and Biolistic gun; practical demonstrations - Detection of transgenes in the exposed plant material; visit to transgenic glasshouse and learning the practical considerations.

#### **Suggested Readings**

- Gardner EJ & Snustad DP. 1991. Principles of Genetics. John Wiley & Sons.
- Klug WS & Cummings MR. 2003. Concepts of Genetics. Peterson Edu.
- Lewin B. 2008. Genes IX. Jones & Bartlett Publ.
- Russell PJ. 1998. Genetics. The Benjamin/Cummings Publ. Co.

- Snustad DP & Simmons MJ. 2006. Genetics. 4th Ed. John Wiley & Sons.
- Strickberger MW. 2005. Genetics (III Ed). Prentice Hall, New Delhi, India
- Tamarin RH. 1999. Principles of Genetics. Wm. C. Brown Publs.
- Uppal S, Yadav R, Subhadra & Saharan RP. 2005. Practical Manual on Basic and Applied Genetics. Dept. of Genetics, CCS HAU Hisar.

## **HOR PG 568: PRINCIPLES OF PLANT BREEDING**

**(2+1)**

### **Theory**

**UNIT I:** History of Plant Breeding (Pre and post-Mendelian era); Objectives of plantbreeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants- Centres of Origin - biodiversity and its significance. Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding; Plant introduction and role of plant genetic resources in plant breeding.

**UNIT II:** Self-incompatibility and male sterility in crop plants and their commercial exploitation. Pure line theory, pure line selection and mass selection methods; Linebreeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops (diallel selective mating approach).

**UNIT III:** Breeding methods in cross pollinated crops; Population breeding - mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and interpopulation improvement and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.

**UNIT IV:** Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection. Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding. Special breeding techniques - Mutation breeding; Breeding for abiotic and biotic stresses. Cultivar development - testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmer's rights.

### **Practical**

Floral biology in self and cross pollinated species, selfing and crossing techniques. Selection methods in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance; Maintenance of experimental records; Learning techniques in hybrid seed production using male-sterility in field and horticultural crops.

## Suggested Readings

- Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.
- Chopra VL. 2001. *Breeding Field Crops*. Oxford & IBH.
- Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.
- Gupta SK. 2005. *Practical Plant Breeding*. Agribios.
- Pohlman JM & Bothakur DN. 1972. *Breeding Asian Field Crops*. Oxford & IBH.
- Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publ. House.
- Sharma JR. 2001. *Principles and Practice of Plant Breeding*. TataMcGraw-Hill.
- Simmonds NW. 1990. *Principles of Crop Improvement*. English Language Book Society.
- Singh BD. 2006. *Plant Breeding*. Kalyani.
- Singh P. 2002. *Objective Genetics and Plant Breeding*. Kalyani.
- Singh P. 2006. *Essentials of Plant Breeding*. Kalyani.
- Singh S & Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.

**HOR PG 569**

**PRINCIPLES OF QUANTITATIVE GENETICS**

**2+1**

### Theory

**UNIT I:** Mendelian traits vs polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions; Nature of gene action - additive, dominance, epistatic and linkage effects.

**UNIT II:** Principles of Analysis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance. Designs for plant breeding experiments - principles and applications; Genetic diversity analysis - micrograph, cluster and D<sup>2</sup> analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models - concepts of selection - heritability and genetic advance.

**UNIT III:** Generation mean analysis; Mating designs - Diallel, partial diallel, line x tester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for GxE analysis and stability parameters; AMMI analysis - principles and interpretation.

**UNIT IV:** QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic analysis; Marker assisted selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.

## Practical

Problems on multiple factors inheritance - Partitioning of variance -Estimation of heritability and genetic advance - Covariance analysis -Metroglyph analysis -  $D^2$  analysis - Grouping of clusters and interpretation- Cluster analysis- Construction of cluster diagrams and dendrograms -interpretation - Correlation analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II – Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and interpretation of results - Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression - Generation mean analysis: Analytical part and Interpretation – Estimation of different types of gene actions. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions -Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model – Principal.

Component Analysis model - Additive and multiplicative model – Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes.

## Suggested Readings

- Bos I & Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
- Falconer DS & Mackay J. 1998. *Introduction to Quantitative Genetics*. Longman.
- Mather K & Jinks JL. 1971. *Biometrical Genetics*. Chapman & Hall.
- Mather K & Jinks JL. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall.
- Nadarajan N & Gunasekaran M. 2005. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani.
- Naryanan SS & Singh P. 2007. *Biometrical Techniques in Plant Breeding*. Kalyani.
- Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani.
- Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani.
- Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
- Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.