- **M.Sc. (Hort.) Fruit Science**

Major courses

Course Code	Course Title	Cr Hrs
	Semester I	
FSC-511*	Tropical Fruit Production	2+1
FSC-512*	Propagation and Nursery Management of Fruit Crops	2+1
FSC-513	Systematics of Fruit Crops	2+1
FSC-514	Organic Fruit Culture	2+1
	Semester II	
FSC-521*	Sub-Tropical and Temperate Fruit Production	2+1
FSC-522*	Breeding of Fruit Crops	2+1
FSC-523	Minor Fruit Production	2+1
FSC-524	Canopy Management in Fruit Crops	1+1
FSC-525	Export Oriented Fruit Production	2+1
	Semester III	
FSC-531	Growth and Development of Fruit Crops	2+1
FSC-532	Nutrition of Fruit Crops	2+1
FSC-533	Biotechnology of Fruit Crops	2+1
FSC-534	Climate Change and Fruit Crops	1+0
	Semester IV	
FSC-591	Seminar	0+1
FSC-599	Research	0+30

*** Core and compulsory courses.**

Note: A student has to opt total 20 credit hours.

Syllabus of Major courses of Fruit Science

FSC-511 TROPICAL FRUIT PRODUCTION (2+1)

THEORY

Block 1: Introduction

Unit I: Importance and Background: Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, national and international importance, eco- physiological requirements.

Block 2: Agro - Techniques

Unit I: Propagation, Planting and Orchard Floor Management: Asexual and sexual methods of propagation, planting systems and planting densities, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of bio- fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Block 3: Crop Management

Unit I: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders - causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

CROPS

Mango, Banana, Guava, Pineapple, Papaya, Avocado, Jackfruit, Annonas, Aonla and Ber

PRACTICALS

- Distinguished features of tropical fruit species, cultivars and rootstocks (2)
- Demonstration of planting systems, training and pruning (3)
- Hands on practices on pollination and crop regulation (2)
- Leaf sampling and nutrient analysis (3)
- Physiological disorders-malady diagnosis (1)

- Physico-chemical analysis of fruit quality attributes (3)
- Field/Exposure visits to tropical orchards (1)
- Project preparation for establishing commercial orchards (1)

RESOURCES

Bartholomew, D.P., Paull, R.E. and Rohrbach, K.G. 2002. *The Pineapple: Botany,Production, and Uses.* CAB International.

Bose, T, K., Mitra, S.K. and Sanyal, D., 2002. *Fruits of India – Tropical and Sub-Tropical*.3rd Edn. Naya Udyog, Kolkata.

Dhillon, W.S., 2013. *Fruit Production in India.* Narendra Publ. House, New Delhi.

Iyer, C. P. A. and Kurian, R. M. 2006. *High Density Planting in Tropical Fruits:Principlesand Practices.* IBDC Publishers, New Delhi.

Litz, R.E. 2009. *The Mango : Botany, Production and Uses*. CAB International.Madhawa Rao, V. N. 2013. *Banana.* ICAR, New Delhi.

Midmore, D. 2015. *Principles of Tropical Horticulture*. CAB International.Mitra, S. K. and Sanyal, D. 2013. *Guava,* ICAR, New Delhi.

Morton, J F. 2013. *Fruits of Warm Climates.* Echo Point Book Media, USA. Nakasome, H. Y and Paull, R. E. 1998. *Tropical Fruits*. CAB International. Paull, R.E. and Duarte, O., 2011. *Tropical Fruits* (Vol. 1). CAB International.

Rani, S., Sharma, A. and Wali, V. K. 2018. *Guava* (*Psidium guajava* L.). Astral, New Delhi.Robinson, J.C. and Saúco, V.G. 2010. *Bananas and Plantains*. CAB International.

Sandhu, S. and Gill, B.S. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi Schaffer, B., Wolstenholme, B. N. and Whiley, A. W. 2013. *The Avocado: Botany,Production and Uses.* CAB International

Sharma, K. K. and Singh, N. P. 2011. *Soil and Orchard Management*. DayaPublishingHouse, New Delhi.

Valavi, S.G., Peter, K.V. and Thottappilly, G., 2011. *The Jackfruit*. Stadium Press, USA.

FSC-512 PROPAGATION AND NURSERY MANAGEMENT IN FRUIT CROPS (2+1)

THEORY

Block 1: Introduction

Unit 1: General Concepts and Phenomena: Introduction, understanding cellular basis for propagation, sexual and asexual propagation, apomixis, polyembryony, chimeras. Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seedgermination and seedling growth. Seed quality, treatment, packing, storage, certification and testing.

Block 2: Propagation

Unit I: Conventional Asexual Propagation: Cutting– methods, rooting of soft and hardwood cuttings under mist and hotbeds. Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

Budding and grafting – principles and methods, establishment and management of bud wood bank. Stock, scion and inter stock relationship - graft incompatibility, physiology of rootstock and top working.

Unit II: Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques - *in vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules.

Block 3: Nursery

Unit I: Management Practices and Regulation: Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, nursery accreditation, import and export of seeds and planting material andquarantine.

PRACTICAL

- Hands on practices on rooting of dormant and summer cuttings (3)
- Anatomical studies in rooting of cutting and graft union(1)
- Hands on practices on various methods of budding and grafting (4)
- Propagation by layering and stooling (2)
- Micropropagation- explant preparation, media preparation, culturing – meristem tipculture, axillary bud culture, micro-grafting, hardening (4)
- Visit to commercial tissue culture laboratories and accredited nurseries (2)

RESOURCES

Bose, T. K., Mitra, S. K. and Sadhu, M.K., 1991. *Propagation of Tropical and SubtropicalHorticultural Crops*. Naya Prokash, Kolkatta.

Davies, F.T,Geneve, R.L. and Wilson, S.B. 2018. *Hartmann and Kester's Plant Propagation-Principles and Practices.* Pearson,USA/PrenticeHall of India. New Delhi.

Gill, S. S., Bal, J. S. and Sandhu, A. S. 2016. *Raising Fruit Nursery*. Kalyani Publishers,NewDelhi.

Jain, S. and Ishil, K. 2003. *Micropropagation of Woody Trees and Fruits*. Springer.

Jain, S. and Hoggmann, H. 2007. *Protocols for Micropropagation of Woody Trees andFruits*. Springer.

Joshi, P. 2015. *Nursery Management of Fruit Crops in India.* NIPA, New Delhi.

Love *et al.*2017. *Tropical Fruit Tree Propagation Guide.* UH-CTAHR F_N_49. CollegeofTropical Agriculture and Human Resources University of Hawaii at Manwa, USA.

Peter, K.V., eds., 2008. *Basics of Horticulture.* New India Publishing Agency, New Delhi. Rajan, S. and Baby, L.M., 2007. *Propagation of Horticultural Crops.* NIPA, New Delhi. Sharma, R.R., 2014. *Propagation of Horticultural Crops.* Kalyani Publishers, New Delhi. Sharma, R.R. and Srivastav, M., 2004. *Propagation and Nursery Management.* Intl. Book

Publishing Co., Lucknow.

Singh, S. P. 1989. *Mist Propagation*. Metropolitan Book Co.

Singh, R. S. 2014. *Propagation of Horticultural Plants : Arid and Semi-Arid Regions.* NIPA,New Delhi.

Tyagi, S. 2019. *Hi-TechHorticulture. Vol I:CropImprovement, Nursery and*

Rootstock Management. NIPA, New Delhi

FSC-513 SYSTEMATICS OF FRUIT CROPS (2+1)

THEORY

Block 1: Biosystematics

UNIT I: Nomenclature and Classification: Biosystematics – introduction and significance ; history of nomenclature of cultivated plants, classification and nomenclature systems ; International code of nomenclature for cultivated plants

Block 2: Botanical Keys and Descriptors

UNIT I: Identification and Description: Methods of identification and description of cultivated fruit and nut species and their wild relatives features ; development of plant keys for systematic identification and classification.

Development of fruit crop descriptors- based upon Bioversity International Descriptors and UPOV/DUS test guidelines, botanical and pomological description of major cultivars and rootstocks of tropical, subtropical and temperate fruits and nut crops

Block 3: Special Topics

UNIT I: Registration and Modern Systematics: Registration, Use of chemotaxonomy, biochemical and molecular markers in modern systematics

PRACTICALS

1. Exercises on identification and pomological description of various fruit species and cultivars(6)
2. Development of descriptive blanks *vis-a-vis* UPOV/DUS test guidelines and Bioversity International(4)
3. Descriptors for developing fruit species and cultivar descriptive databases(4)
4. Visits to major germplasm centres and field genebanks (2)

RESOURCES

ASHS, 1997. *The Brooks &Olmo Register of Fruit and NutVarieties*. 3rd Ed. ASHS Press. Bhattacharya, B. and Johri, B.M. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Pub. House, New Delhi.

Pandey, B.P. 1999. *Taxonomy of Angiosperms*. S. Chand & Co. New Delhi.

Pareek, O.P. and Sharma, S., 2017. *Systematic Pomology*. Scientific Publishers, Jodhpur. Sharma,G.,Sharma,O.C.andThakur, B.S. 2009. *Systematics of Fruit Crops*. NIPA, N.Delhi.Simpson, M. 2010. *Plant Systematics*. 2ndEdn. Elsevier.

Spencer, R.R. Cross, R. and Lumley, P. 2003. *Plant Names*. 3rd Ed. *A Guide to Botanical Nomenclature,* CISRO, Australia.

Srivastava, U, Mahajan, R.K., Gangopadyay, K.K., Singh, M. and Dhillon, B.S. 2001. *Minimal Descriptors of Agri-Horticultural Crops.I: Fruits*. NBPGR, New Delhi. Zielinski, Q. B. 1955. *Modern Systematic Pomology.* Wm. C. Brown Co., Iowa, USA.

FSC-514 ORGANIC FRUIT CULTURE (2+1)

THEORY

Block 1: General Aspects

UNIT I: Principles and Current Scenario: Organic horticulture, scope, area, production and world trade, definition, principles, methods and SWOT analysis.

Block 2: Organic Culture

UNIT I: Farming System and Practices: Organic farming systems including biodynamic farming, natural farming, homa organic farming, rishi krishi, EM technology, cosmic farming
; on-farm and off-farm production of organic inputs, role of bio-fertilizers, bio enhancers, legumes, inter cropping, cover crops, green manuring, zero tillage, mulching and their role in organic nutrition management. Organic seeds and planting materials, soil health managementin organic production, weed management practices in organic farming, biological management of pests and diseases, trap crops, quality improvement in organic production of fruit crops.

Block 3: Certification

UNIT I: Inspection, Control Measures and Certification: Inspection and certification of organic produce, participatory guarantee system (PGS), NPOP, documentation and control, development of internal control system (ICS), Concept of group certification, constitution of grower group as per NPOP, preparation of ICS manual, internal and external inspection,concept of third party verification, certification of small farmer groups (Group Certification),transaction certificate, group certificate, critical control points (CCP) and HACCP, IFOAM guidelines on certification scope and chain of custody, certification trademark – The Logo, accredited certification bodies under NPOP. Constraints in certification, IFOAM and global scenario of organic movement, postharvest management of organic produce. Economics of organic fruit production

PRACTICALS

1. Design of organic orchards/farms management(1)
2. Conversion plan(1)
3. Nutrient management and microbial assessment of composts and bio-enhancers(2)
4. Preparation and application of composts, bio-enhancers and bio-pesticides(2)
5. Organic nursery raising (1)
6. Application of composts, bio-enhancers, bio-fertilisers and bio-pesticides, greenmanure, cover, mulching (2)
7. Preparation and use of neem based products(1)
8. Biodynamic preparations and their role in organic agriculture, EM technology andproducts, biological/natural management of pests and diseases(2)
9. Soil solarisation (1)
10. Frame work for GAP(1)
11. Documentation for certification(1)

RESOURCES

Claude, A. 2004. *The Organic Farming Sourcebook*. Other India Press, Mapusa, Goa, India.Dabholkar, S.A. 2001. *Plenty for All.* Mehta Publishing House, Pune, Maharashtra.

Das, H.C. and Yadav, A. K. 2018. *Advances in Organic Production of Fruit Crops.* Westville Publishing House, New Delhi.

Deshpande, M.S. 2003. *Organic Farming with respect to Cosmic Farming.* Mrs. PushpaMohan Deshpandey, Kolhapur, Maharashtra.

Deshpande, W. R. 2009. *Basics of Organic Farming*. All India Biodynamic and OrganicFarming Association, Indore. M.P.

Gaur, A.C., Neblakantan, S. and Dargan, K.S. 1984 *Organic Manures*. ICAR., New DelhiLampkin, N. and Ipswich, S. 1990. *Organic Farming*. Farming Press. London, UK.

Lind, K., Lafer, G., Schloffer, K., Innershofer, G. And Meister, H. 2003. *Organic FruitGrowing.* CAB International

Palaniappan, S.P. and Annadurai, K. 2008. *Organic Farming- Theory and Practice*. Scientific Publishers, Jodhpur, Rajasthan, India.

Palekar, S. 2004. *The Technique of Spritual Farming*. Chandra Smaritee, Sai Nagar,Amrawati, Maharashtra.
Proctor, P. 2008. Biodynamic Farming and Gardening. Other India Press, Mapusa, Goa. Ram, R.A. and Pathak, R.K. 2017. Bioenhancers. Lap Lambert Academic Publishing, A.P.

FSC-521 SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION (2+1)

THEORY

Block 1: Introduction

Unit I: Importance and Background: Origin, distribution and importance, major species, rootstocks and commercial varieties of regional, national and international importance, eco- physiological requirements.

Block 2: Agro - Techniques

Unit I: Propagation, Planting and Orchard Floor Management: Propagation, planting systems and densities, training and pruning, rejuvenation and replanting, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Block 3: Crop Management

Unit I: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders- causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

CROPS

Citrus, Grapes, Litchi, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherries, Berries, Persimmon, Kiwifruit, Nuts- Walnut, Almond and Pecan

PRACTICALS

1. Distinguished features of fruit species, cultivars and rootstocks (2)
2. Demonstration of planting systems, training and pruning (3)
3. Hands on practices on pollination and crop regulation (2)
4. Leaf sampling and nutrient analysis (3)
5. Physiological disorders-malady diagnosis (1)
6. Physico-chemical analysis of fruit quality attributes (3)
7. Field/Exposure visits to subtropical and temperate orchards (1)
8. Project preparation for establishing commercial orchards (1)

RESOURCES

Chadha, K.L. and Awasthi, R.P. 2005. *The Apple*. Malhotra Publishing House, New Delhi.Chadha, T.R. 2011. *A Text Book of Temperate Fruits*. ICAR, New Delhi
Childers, N. F., Morris, J. R. and Sibbett, G. S. 1995. *Modern Fruit Science : Orchard andSmall Fruit Culture*. Horticultural Publications, USA.
Creasy, G and Creasy L. 2018. *Grapes.* CAB International. Davies, F.S. and Albrigo, L.G., 1994. *Citrus.* CAB International.
Dhillon, W.S., 2013. *Fruit Production in India.* Narendra Publishing House, New Delhi. Jackson, D., Thiele, G., Looney, N. E. and Morley-Bunker, M. 2011. *Temperate and Subtropical Fruit Production.* CAB International.
Ladanyia, M., 2010. *Citrus Fruit : Biology, Technology and Evaluation*. Academic Press.Layne, D.R. and Bassi, D. 2008. *The Peach: Botany, Production and Uses*. CABI.
Menzel, C. M. and Waite, G. K. 2005. *Litchi and Longan: Botany, Production and Uses*. CAB International.
Pandey , R. M. and Randey, S. N. 1996. *The Grape in India*. ICAR, New Delhi. Rajput, C.B.S. and Haribabu, R.S. 2006. *Citriculture,* Kalyani Publishers, New Delhi.
Sandhu, S. and Gill, B. S. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi. Sharma, R. M., Pandey, S. N. and Pandey, V. 2015. *The Pear - Production, Post- harvest Management and Protection*. IBDC Publisher, New Delhi.
Sharma, R. R. and Krishna, H., 2018. *Textbook of Temperate Fruits.* CBS Publishers andDistributors

Pvt. Ltd., New Delhi.
Singh, S., Shivshankar, V. J, Srivastava, A. K. and Singh I. P. 2004. *Advances in Citriculture.* NIPA, New Delhi.
Tromp, J., Webster, A. S. and Wertheim, S. J. 2005. *Fundamentals of Temperate Zone TreeFruit Production.*Backhuys Publishers, Lieden, The Netherlands.\
Webster, A. and Looney, N. *Cherries : Crop Physiology, Production and Uses.* CABI. Westwood, M. N. 2009. *Temperate Zone Pomology:Physiology&Culture.* Timber Press, USA.

FSC-522 BREEDING OF FRUIT CROPS (2+1)

THEORY

Block 1: Introduction

Unit I: Importance, Taxonomy and Genetic Resources: Introduction and importance, origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources.

Block 2: Reproductive Biology

Unit I: Blossom Biology and Breeding Systems: Blossom biology, breeding systems – spontaneous mutations, polyploidy, incompatibility, sterility, parthenocarpy, apomixis, breeding objectives, ideotypes.

Block 3: Breeding Approaches

Unit I: Conventional and Non-Conventional Breeding: Approaches for crop improvement – direct 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 thrusts.

CROPS

Mango, Banana, Pineapple, Citrus, Grapes, Litchi, Guava, Pomegranate, Papaya, Apple, Pear, Plum, Peach, Apricot, Cherries, Strawberry, Kiwifruit, Nuts

PRACTICAL

- Exercises on bearing habit, floral biology(2)
- Pollen viability and fertility studies(1)
- Hands on practices in hybridization(3)
- Raising and handling of hybrid progenies(2)
- Induction of mutations and polyploidy(2)
- Evaluation of biometrical traits and quality traits(2)
- Screening for resistance against abiotic stresses (2)
- Developing breeding programme for specific traits (2)
- Visit to research stations working on fruit breeding (1)

RESOURCES

Abraham, Z. 2017. *Fruit Breeding*. Agri-Horti Press, New Delhi.
Badenes, M. L. and Byrne, D. H. 2012. *Fruit Breeding*. Springer Science, New York.Dinesh, M. R. 2015. *Fruit Breeding*, New India Publishing Agency, New Delhi.
Ghosh, S. N. Verma, M. K. and Thakur, A. 2018. *Temperate Fruit Crop Breeding-Domestication to Cultivar Development.* NIPA, New Delhi.
Hancock, J. F. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. SpringerScience, New York.
Jain, S. N. and Priyadarshan, P. M. 2009. *Breeding Plantation and Tree Crops: Tropical Species.* Springer Science, New York.
Jain, S. and Priyadarshan, P. M. 2009. *Breeding Plantation and Tree Crops: TemperateSpecies*. Springer Science, New York.
Janick, J. and Moore, J. N. 1996. *Fruit Breeding*. Vols. I - III. John Wiley & Sons, USA. Kumar, N. 2014. *Breeding of Horticultural Crops:Principles& Practices*. NIPA, N. Delhi. Moore, J. N. and Janick,

J. 1983. *Methods in Fruit Breeding*. Purdue University Press, USA.Ray. P. K.2002. *Breeding Tropical and Subtropical Fruits.*Narosa Publ. House, New Delhi.

FSC-523 MINOR FRUIT PRODUCTION (2+1)

THEORY

Block 1: Introduction

UNIT I: Occurrence, Adoption and General Account: Importance – occurrence anddistribution, climate adaptation in fragile ecosystem and wastelands.

Block 2: Agro-Techniques

UNIT I: Propagation and Cultural Practices: Traditional cultural practices and recent development in agro-techniques; propagation, botany-floral biology, growth patterns, modeof pollination, fruit set, ripening, fruit quality.

Block 3: Marketing and Utilization

UNIT I: Post-Harvest Management: Post harvest management, marketing ; minor fruit cropsin terms of medicinal and antioxidant values ; their uses for edible purpose and in processing industry

CROPS:

Bael, chironji, fig, passionfruit, jamun, phalsa, karonda, woodapple, Cactus pear, khejri, kair, pilu, lasoda, loquat, tamarind, dragon fruit, monkey jack, mahua, khirni, amra, kokum, cape gooseberry, kaphal, persimmon, pistachio, seabuckthorn, hazel nut and Other minor fruits of regional importance

PRACTICALS

- Visits to institutes located in the hot and cold arid regions of the country(2)
- Identification of minor fruits plants/cultivars(2)
- Collection of leaves and preparation of herbarium(1)
- Allelopathic studies(2)
- Generating know-how on reproductive biology of minor fruits(4)
- Fruit quality attributes and biochemical analysis(3)
- Project formulation for establishing commercial orchards in fragile ecosystems(1)

RESOURCES

Ghosh, S. N., Singh, A. and Thakur, A. 2017. *Underutilized Fruit Crops: Importance andCultivation.* Jaya Publication House, New Delhi.

Krishna, H. and Sharma, R.R., 2017. *Fruit Production :Minor Fruits.*Daya Publishing House,New Delhi

Mazumdar, B. C. 2014. *Minor Fruit Crops of India: Tropical and Subtropical*. DayaPublication House, New Delhi

Nath, V., Kumar, D., Pandey, V. and Pandey, D., 2008. *Fruits for the Future*. Satish SerialPublishing House, New Delhi.

Pareek, O. P., Sharma, S. and Arora, R. K., 2007. *Underutilised Edible Fruits and Nuts*,IPGRI, Rome.

Peter, K.V., 2010. *Underutilized and Underexploited Horticultural Crops*. NIPA, New Delhi.

Rana, J. C. and Verma, V. D. 2011. *Genetic Resources of Temperate Minor Fruit(Indigenous and Exotic)*. NBPGR, New Delhi.

Saroj, P. L. and Awasthi, O. P., 2005. *Advances in Arid Horticulture*, Vol. II: *ProductionTechnology of Arid and Semiarid Fruits*. IBDC, Lucknow.

Saroj, P. L., Dhandar, D. G. and Vashishta, B.B. 2004. *Advances in Arid Horticulture*, Vol.-1 *Present Status*. IBDC, Lucknow.

Singh *et al*., 2011. *Jamun*. ICAR, New Delhi.

FSC-524 CANOPY MANAGEMENT OF FRUIT CROPS (1+1)

THEORY

Block 1: Canopy Architecture

UNIT I: Introduction, Types and Classification: Canopy management - importance and factors affecting canopy development. Canopy types and structures, canopy manipulation for optimum utilization of light and its interception. Spacing and utilization of land area - Canopy classification.

Block 2: Canopy Management

UNIT I: Physical Manipulation and Growth Regulation: Canopy management through rootstock and scion. Canopy management through plant growth regulators, training and pruning and management practices. Canopy development and management in relation to growth, flowering, fruiting and fruit quality.

PRACTICALS

1. Study of different types of canopies (2)
2. Training of plants for different canopy types(2)
3. Canopy development through pruning (2)
4. Understanding bearing behaviour and canopy management in different fruits(2)
5. Use of plant growth regulators(2)
6. Geometry of planting(1)
7. Development of effective canopy with support system(2)
8. Study on effect of different canopy types on production and quality of fruits(2)

RESOURCES

Bakshi, J.C.,Uppal, D.K. and Khajuria, H.N. 1988. *The Pruning of Fruit Trees and Vines*. Kalyani Publishers, New Delhi.

Chadha, K. L. and Shikhamany, S. D., 1999. *The Grape, Improvement, Production and PostHarvest Management*. Malhotra Publishing House, Delhi.

Iyer, C. P. A. and Kurian, R. M. 2006. *High Density Planting in Tropical Fruits: Principlesand Practices.* IBDC Publishers, New Delhi.

Pradeepkumar, T. 2008. *Management of Horticultural Crops*. NIPA, New Delhi.

Singh, G. 2010. *Practical Manual on Canopy Management in Fruit Crops.* Dept. ofAgriculture and Co-operation ,Ministry of Agriculture (GoI), New Delhi.

Srivastava, K. K., 2012. *Canopy Management in Fruits*. ICAR, New Delhi

FSC-525 EXPORT ORIENTED FRUIT PRODUCTION (2+1)

THEORY

Block 1: Introduction

UNIT I: Statistics and World Trade: National and international fruit export and import scenario and trends ; Statistics and India's position and potentiality in world trade ; export promotion zones in India. Government Policies.

Block 2: Regulations

UNIT I: Policies, Norms and Standards: Scope, produce specifications, quality and safetystandards for export of fruits *viz*., mango, banana, grape, litchi, pomegranate, walnut, appleand other important fruits. Processed and value-added products, post harvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; WTO and its implications, sanitary and phyto-sanitary measures.

Block 3: Quality Assurance

UNIT I: Infrastructure and Plant Material: Quality fruit production under protected environment; different types of structures – Automated greenhouses, glasshouse, shade net,poly tunnels - Design and development of low cost greenhouse structures. Seed and planting material; meeting export standards, implications of plant variety protection – patent regimes.

PRACTICALS

1. Export promotion zones and export scenario of fresh fruits and their products(1)
2. Practical exercises on quality standards of fruits for export purpose(2)

3. Quality standards of planting material and seeds(2)
4. Hi-tech nursery in fruits(1)
5. Practicals on ISO specifications and HACCP for export of fruits(3)
6. Sanitary and phyto-sanitary measures during export of horticultural produce(2)
7. Post harvest management chain of horticultural produce for exports(2)
8. Visit to export oriented units/agencies like APEDA, NHB, etc.

FSC-531 GROWTH AND DEVELOPMENT OF FRUIT CROPS (2+1)

THEORY

Block 1: Introduction

UNIT I: General Concepts and Principles: Growth and development- definition, parametersof growth and development, growth dynamics and morphogenesis.

Block 2: Environment and Development

UNIT I: Climatic Factors, Hormones and Developmental Physiology: Environmental impacton growth and development- effect of light, temperature, photosynthesis and photoperiodism, vernalisation, heat units and thermoperiodism. Assimilate partitioning, influence of water and mineral nutrition in growth and development; concepts of plant hormone and bioregulators, history, biosynthesis and physiological role of auxins, gibberellins, cytokinins, abscissic acid, ethylene, growth inhibitors and retardant, brasssinosteroids, other New PGRs. 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.

Block 3: Stress Management

UNIT I: Strategies for Overcoming Stress: Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemicalmanipulations and Commercial application of PGRs in fruit crops, molecular and geneticapproaches in plant growth and development.

PRACTICALS

1. Understanding dormancy mechanisms in fruit crops and seed stratification (2)
2. Techniques of growth analysis(2)
3. Evaluation of photosynthetic efficiency under different environments(2)
4. Exercises on hormone assays(2)
5. Practicals on use of growth regulators(2)
6. Understanding ripening phenomenon in fruits(2)
7. Study on impact of physical manipulations on growth and development(1)
8. Study on chemical manipulations on growth and development(1)
9. Understanding stress impact on growth and development(1)

RESOURCES

Bhatnagar, P. 2017. *Physiology of Growth and Development of Horticultural Crops*. Agrobios (India).

Buchanan, B., Gruiessam, W. and Jones, R. 2002. *Biochemistry and Molecular Biology ofPlants*. John Wiley & Sons, NY, USA.

Dhillon, W.S. and Bhatt, Z. A., 2011. *Fruit Tree Physiology.* Narendra Publishing House,New Delhi.

Durner, E. 2013. *Principles of Horticultural Physiology.* CAB International.

Epstein, E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. John Wiley &Sons, NY, USA.

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Roberts, J., Downs, S. and Parker, P., 2002. *Plant Growth Development*. In: Salisbury, F.B. and Ross, C.W. (Eds.) *Plant Physiology*.4th Ed.Wadsworth Publications, USA.
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Seymour, G. B., Taylor, J. E. and Tucker, G.A.,1993. *Biochemistry of Fruit Ripening*. Chapman & Hall, London

FSC-532 NUTRITION OF FRUIT CROPS (2+1)

THEORY

Block 1: Introduction

UNIT I: General Concepts and Principles: Importance and history of nutrition in fruit crops, essential plant nutrients, factors affecting plant nutrition; nutrient uptake and their removal from soil.

Block 2: Requirements and Applications

UNIT I: Diagnostics, Estimation and Application: Nutrient requirements, root distribution in fruit crops, soil and foliar application of nutrients in major fruit crops, fertilizer use efficiency. Methods and techniques for evaluating the requirement of macro- and micro- elements, Diagnostic and interpretation techniques including DRIS. Role of different macro-and micro-nutrients, their deficiency and toxicity disorders, corrective measures to overcome deficiency and toxicity disorders.

Block 3: Newer Approaches

UNIT I: Integrated Nutrient Management (INM): Fertigation in fruit crops, bio-fertilizers and their use in INM systems.

PRACTICALS

1. Visual identification of nutrient deficiency symptoms in fruit crops (2)
2. Identification and application of organic, inorganic and bio-fertilizers(1)
3. Soil/tissue collection and preparation for macro- and micro-nutrient analysis(1)
4. Analysis of soil physical and chemical properties- pH, EC, Organic carbon(1)
5. Determination of N,P,K and other macro- and micronutrients (6)
6. Fertigation in glasshouse and field grown horticultural crops(2)
7. Preparation of micro-nutrient solutions, their spray and soil applications(2)

RESOURCES

Atkinson , D., Jackson, J. E. and Sharples, R . O. 1980. *Mineral Nutrition of Fruit Trees.* Butterworth – Heinemann.
Bould, C., Hewitt, E.J. and Needham, P. 1983. *Diagnosis of Mineral Disorders in PlantsVol.1 Principles.* Her Majesty's Stationery Office, London.
Cooke, G.W. 1972. *Fertilizers for maximizing yield*. Grenada Publishing Ltd, London. Epstein, E. 1972. *Mineral Nutrition of Plants: Principles & Perspectives*. Wiley Eastern Ltd.Kanwar, J.S. 1976. Soil Fertility- Theory and Practice. ICAR, New Delhi.
Marchner, Horst. 1995. *Mineral Nutrition of Higher Plants*, 2nd Ed. Marschner, AcademicPress Inc. San Diego, CA.
Mengel, K. and Kirkby, E.A. 1987. *Principles of Plant Nutrition*. 4th Ed. International PotashInstitute, Worblaufen-Bern, Switzerland.
Prakash, M. 2013. *Nutritional Disorders in Fruit Crops: Diagnosis and Management*. NIPA,New Delhi.
Tandon, H.L.S. 1992. *Management of Nutrient Interactions in Agriculture*. FertilizerDevelopment and Consultation Organization, New Delhi.
Westerman, R.L. 1990. *Soil Testing and Plant Analysis*, 3rd Ed. Soil Science Society ofAmerica, Inc., Madison, WI.
Yawalkar, K.S., Agarwal, J.P. and Bokde, S. 1972. *Manures and Fertilizers*. 3rd Ed. AgriHorticultural Publishing House, Nagpur.

FSC-533 BIOTECHNOLOGY OF FRUIT CROPS (2+1)

THEORY

Block 1: General Background

UNIT I: Introduction, History and Basic Principles: Introduction and significance, history and basic principles, influence of explant material, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture

Block 2: Tissue Culture

UNIT I: *In vitro* Culture and Hardening: Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis ; Organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture. Use of bioreactors and*in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues. Hardening and *ex vitro* establishment of tissue cultured plants

Block 3: Genetic Manipulation

UNIT I: *In vitro* Breeding, Transgenics and Gene Technologies: Somatic cell hybridisation, construction and identification of somatic hybrids and cybrids, wide hybridization, *in vitro* pollination and fertilization, haploids, *in vitro* mutation, artificial seeds, cryopreservation, *In vitro* selection for biotic and abiotic stress. Genetic engineering- principles and methods,

transgenics in fruit crops, use of molecular markers and genomics. Gene silencing, genetagging, gene editing, achievements of biotechnology in fruit crops.

PRACTICALS

1. An exposure to low cost, commercial and homestead tissue culture laboratories(2)
2. Media preparation, Inoculation of explants for clonal propagation, callus inductionand culture, regeneration of plantlets from callus(3)
3. Sub -culturing techniques on anther, ovule, embryo culture, somaclonalvariation(4)
4. *In vitro* mutant selection against abiotic stress(2)
5. Protoplast culture and fusion technique(2)
6. Development of protocols for mass multiplication(2)
7. Project development for establishment of commercial tissue culture laboratory(1)

RESOURCES

Bajaj, Y.P.S., Eds., 1989. *Biotechnology in Agriculture and Forestry*. Vol. V, *Fruits*. Springer, USA.

Brown, T,A., 2001. *Gene Cloning and DNA Analysis and Introduction.* BlackwellPublishing, USA.

Chahal, G.S. and Gosal, S.S., 2010. *Principles and Procedures of Plant Breeding:Biotechnological and Conventional Approaches*. Narosa, New Delhi.

Chopra, V.L. and Nasim, A., 1990. *Genetic Engineering and Biotechnology – Concepts,Methods and Applications.* Oxford & IBH, New Delhi.

Keshavachandran, R. and Peter, K.V. 2008. *Plant Biotechnology: Tissue Culture and GeneTransfer*. Orient & Longman, Universal Press, US.

Keshavachandran. R., Nazeem, P.A., Girija, D., John, P.S. and Peter, K.V. 2007. *RecentTrends in Biotechnology of Horticultural Crops*. Vols. I, II. NIPA, New Delhi.

Kale, C. 2013. Genome Mapping and Molecular Breeding in Plant. Vol 4 Fruit and Nuts. Springers

Litz, R. E. 2005. *Biotechnology of Fruit and Nut Crops.* CABI, UK.

Miglani, G.S. 2016. *Genetic Engineering – Principles, Procedures and Consequences*. Narosa Publishing House, New Delhi.

Parthasarathy, V.A,, Bose, T.K., Deka, P.C., Das, P., Mitra, S.K. and Mohanadas, S., 2001. *Biotechnology of Horticultural Crops*. Vols. I-III. Naya Prokash, Kolkata.

Peter, K.V.2013. *Biotechnology in Horticulture:Methods& Applications*. NIPA, New Delhi.Vasil, T.K., Vasi, M., While, D.N.R. and Bery, H.R. 1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture*.PlatinumPress, UK.

FSC-534 CLIMATE CHANGE AND FRUIT CROPS (1+0)

THEORY

Block 1: General Aspects

UNIT I: Introduction, Global Warming and Climatic Variability: Introduction to climate change. Factors directly affecting climate change. Global warming, effect of climate changeon spatio-temporal patterns

of temperature and rainfall, concentrations of greenhouse gassesin atmosphere. pollution levels such as tropospheric ozone, change in climatic variability and extreme events.

Block 2: Climate Change and Management

UNIT I: Impact Assessment and Mitigation: Sensors for recording climatic parameters, plants response to the climate changes, premature bloom, marginally overwintering or inadequate winter chilling hours, longer growing seasons and shifts in plant hardiness for fruit crops.

Climate mitigation measures through crop management- use of tolerant rootstocks and varieties, mulching - use of plastic- windbreak- spectral changes- protection from frost and heat waves. Climate management in greenhouse- heating - vents - CO_2 injection - screens - artificial light. Impact of climate changes on invasive insect, disease, weed, fruit yield, quality and sustainability. Climate management for control of pests, diseases, quality, elongation of growth and other plant processes- closed production systems.

Block 3: Case Studies

UNIT I: Response to Climate Change: Case studies – responses of fruit trees to climatic variability *vis-a-vis* tolerance and adaptation ; role of fruit tree in carbon sequestration.

RESOURCES

Dhillon, W.S. and Aulakh, P.S. 2011. *Impact of Climate Change in Fruit Production*. Narendra Publishing House, New Delhi.

Peter, K.V. 2008. *Basics in Horticulture*. New India Publishing Agency, New Delhi.

Ramirez , F. and Kallarackal, J. 2015. *Responses of Fruit Trees to Global Climate Change*. Spinger- Verlag.

Rao, G.S.L.H.V. 2008. *Agricultural Meteorology*. Prentice Hall, New Delhi.

Rao, G.S.L.H.V., Rao, G.G.S.N., Rao, V.U.M. and Ramakrishnan, Y.S. 2008. *ClimateChange and Agriculture over India*. ICAR, New Delhi.

Schafeer, B. and Anderson, P. 1994. *Handbook of Environmental Physiology of FruitCrops*.Vol. 1 & 2. CRC Press. USA.