(I) Ph. D. (Hort.) Fruit Science

Major Courses

Course Code	Course Title	
	Semester I	
FSC 611*	Innovative Approaches in Fruit Breeding	3+0
FSC 612*	Modern Trends in Fruit Production	3+0
FSC 613	Recent Developments in Growth Regulation	3+0
FSC 614	Advanced Laboratory Techniques	1+2
	Semester II	
FSC 621	Arid and Dry Land Fruit Production	2+0
FSC 622	Abiotic Stress Management in Fruit Crops	2+1
FSC 623	Biodiversity and Conservation of Fruit Crops	2+1
FSC 624	Smart Fruit Production	2+0
	Semester III	
FSC 691	Seminar-I	0+1
	Semester IV	
FSC 691	Seminar-II	0+1
	Semester V & VI	
FSC 699	Research	0+75

**Compulsory among major courses*

Syllabus of Major courses of Ph.D. (Hort.) Fruit Science

FSC- 611 INNOVATIVE APPROACHES IN FRUIT BREEDING (3+0)
THEORY

Block 1: Introduction

UNIT I: Current Trends and Status: Modern trends in fruit breeding –with major emphasis on precocity, low tree volume, suitability for mechanization, health benefits etc.

Block 2: Genetic Mechanisms

UNIT I: Inheritance Patterns and Breeding Systems: Genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits.

Block 3: Breeding for Specific Traits

UNIT I: Plant Architecture, Stress Tolerance and Fruit Quality: Recent advances in cropimprovement efforts- wider adaptation, plant architecture, amenability to mechanization, fruit quality attributes, stress tolerance, crop specific traits ; use of apomixis, gene introgressionand wide hybridization (alien genes).

Block 4: Fast- Track Breeding

UNIT I: Transgenics, Markers and Genomics: Molecular and transgenic approaches in improvement of selected fruit crops ; fast track breeding – marker assisted selection andbreeding (MAS and MAB), use of genomics and gene editing tehnologies.

CROPS:

Mango, banana, guava, papaya, Citrus, grapes, pomegranate, litchi, apple, pear, strawberry, kiwifruit,

plums, peaches, apricot, cherries, nectarines, nut crops

RESOURCES

Al-Khayari , J., Jain, S. N. and Johnson, D. V. 2018. *Advances in Plant Breeding Strategies. Vol. 3: Fruits.* Springer

Badenes, S. and Byrne, D.H. 2012. *Fruit Breeding*. Springer.

Hancock, J. F. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. Springer Kole, C. and Abbott, A. G. 2012. *Genetics, Genomics and Breeding of Stone fruits.* CRC Kole, C. 2011. *Wild Crops Relatives: Genomics and Breeding Resources: Tropical and Subtropical Fruits.* Springer-Verlag

Kole, C. 2011. *Wild Crops Relatives: Genomics and Breeding Resource: Temperate Fruits.* Springer -Verlag.

Jain, S. N. and Priyadarshan, P. M. 2009. *Breeding Plantation and Tree Crops: TropicalSpecies*; *Temperate Species*. Springer -Verlag.

Janick, J. and Moore, J.N., 1996. *Fruit Breeding*. Vols.I-III. John Wiley & Sons, USA.Orton, T. 2019. *Methods in Fruit Breeding*. Elsevier.

Singh, S.K., Patel, V.B., Goswami, A.K., Jai Prakash and Chavlesh Kumar.2019. *Breeding ofPerennial Horticultural Crops*. Biotech Books. Delhi

FSC-612 MODERN TRENDS IN FRUIT PRODUCTION (3+0)

THEORY

Block 1: Introduction

UNIT I: General Concepts and Current Scenario: National and International scenario,national problems.

Block 2: Advanced Technologies

UNIT I: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation - root stocks, planting systems, High density planting, crop modeling, Precision farming,decision support systems - aspects of crop regulation- physical and chemical regulation.

Block 3: Management Practices

UNIT I: Overcoming Stress and Integrated Approaches: Effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Physiological disorders, Total quality management (TQM) - Current topics.

CROPS:

Mango, Banana, Grapes, Citrus, Papaya, Litchi, Guava, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherry, Almond, Walnut, Pecan, Strawberry, Kiwifruit

RESOURCES

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

Bose, T.K,, Mitra, S.K. and Sanyol, D., Eds., 2002. *Fruits of India – Tropical and Sub-Tropical*. 3rd Ed. Vols. I, II. Naya Udyog, Kolkata, India.

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

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

Gowen, S., 1995. *Bananas and Plantains*. Chapman & Hall Publication, US.

Litz, R.E. ed., 2009. *The Mango: Botany, Production and Uses*. CAB International.Peter, K. V. 2016. *Innovations in Horticulture*. NIPA, New Delhi.
Robinson, J.C. and Saúco, V.G., 2010. *Bananas and Plantains* (Vol. 19). CAB International.
Samson, J.A., 1980. *Tropical Fruits*. Longman, USA.
Sharma, R.R. and Krishna, H. 2014. *Fruit Production: Major Fruits*. Daya Publishing House,Delhi.
Singh, S., Shivankar, V.J., Srivastava, A.K. and Singh, I.P. 2004. *Advances in Citriculture*. Jagmander Book Agency, New Delhi.
Stover, R.H. and Simmonds, N.W. 1991. *Bananas*. Longman, USA
Chadha, K.L., Ahmed, N., Singh, S.K., Kalia P. 2016. *Temperate Fruits and Nuts- Way Forward for Enhancing Production and Quality.*Daya Publishing House, New Delhi Childers, N. F., Morris, J. R. and Sibbett, G. S. 1995. *Modern Fruit Science: Orchard and Small Fruit Culture.* Horticultural Publications, USA.
Erez, A. 2013. *Temperate Fruit Crops in Warm Climates*. Springer Science. Jackson, D., Thiele, G., Looney, N. E. and Morley-Bunker, M. 2011. *Temperate and Subtropical Fruit Production.* CAB International
Ryugo, K. 1998. *Fruit Culture: Its Science and Art.* John Wiley & Sons, USA.
Tromp, J., Webster, A. S. and Wertheim, S. J. 2005. *Fundamentals of Temperate Zone TreeFruit Production. Backhuys Publishers,*Lieden, The Netherlands.
Westwood, M. N. 2009. *Temperate Zone Pomology : Physiology and Culture.* 3rdEdn. Timber Press, USA.

FSC-613 RECENT DEVELOPMENTS IN GROWTH REGULATION (3+0)
THEORY

Block 1: Introduction

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

Block 2: Growth Substances

UNIT I: Phytohormones and Growth Regulators: Root and canopy regulation, study of plant growth regulators in fruit culture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants. Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal

synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards.

Block 3: Growth and Development

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

Flower drop and thinning, fruit-set and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, molecular approaches in crop growth regulation- current topics.

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, US.
Fosket, D,E. 1994. *Plant Growth and Development : A Molecular Approach.* AcademicPress, USA.
Leopold, A.C and Kriedermann, P.E., 1985. *Plant Growth and Development*. 3rd Ed. McGraw-Hill, US.

Richard N. Arteca, 1995. *Plant Growth Substances – Principles and Applications*. Chapman& Hall, USA.
Roberts, J., Downs, S. and Parker, P., 2002. *Plant Growth Development*. In: *Plants* (I. Ridge,Ed.), Oxford University Press.
Salisbury, F.B. and Ross, C.W., 1992. *Plant Physiology*. 4th Ed. Wadsworth Publication.

FSC-614 ADVANCED LABORATORY TECHNIQUES (1+2)
THEORY
Block 1: General Aspects
UNIT 1: Safety Measures and Laboratory Maintenance: Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.

Block 2: Qualitative and Quantitative Analysis
UNIT I: Destructive and Non-destructive Analysis Methods: Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starchin food crops.
UNIT II: Chromatographic and Microscopic Analysis: Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an indexof membrane permeability, determination of biochemical components in horticultural produce.
UNIT III: Sensory Analysis: Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control oftest rooms, products and panel.

PRACTICALS
- Determination of moisture, relative water content and physiological loss in weight(2)
- Determination of biochemical components in horticultural produce(3)
- Calibration and standardization of instruments(1)
- Textural properties of harvested produce(1)
- Determination of starch index (SI) (1)
- Specific gravity for determination of maturity assessment, and pH of produce(1)
- Detection of adulterations in fresh as well as processed products(2)
- Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugarsand starch(2)
- Estimation of rate of ethylene evolution using gas chromatograph (GC) (2)
- Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, etc.) (2)

RESOURCES
AOAC International. 2003. *Official Methods of Analysis of AOAC International*. 17th Ed.Gaithersburg, MD, USA, Association of Analytical Communities, USA.

Clifton, M. and Pomeranz,Y.1988. *Food Analysis-Laboratory Experiments*. AVI Publication,USA.
Linskens, H. F. And Jackson, J. F. 1995. *Fruit Analysis.* Springer.
Leo, M.L. 2004. *Handbook of Food Analysis*. 2nd Ed. Vols. I-III, USA.
Pomrenz, Y. and Meloan, C.E. 1996. *Food Analysis - Theory & Practice*. CBS, USA. Ranganna, S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. 2nd Ed. Tata-McGraw-Hill, New Delhi.
Thompson, A.K. 1995. *Post Harvest Technology of Fruits and Vegetables*. BlackwellSciences. A.

FSC-621 ARID AND DRYLAND FRUIT PRODUCTION (2+0)

THEORY

Block 1: Introduction

UNIT I: General Concepts and Current Scenario: Characteristics features and majorconstraints of the arid and dryland region, distinguishing features of the fruit species trees for adaptation in adapting to the region, nutritional and pharmaceutical importance, nationalproblems.

Block 2: Advanced Technologies

UNIT I: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation - root stocks, planting systems, High density planting, crop modelling, Precision farming, decision support systems - aspects of crop regulation- physical and chemical regulation, effects on physiology and development, influence of stress factors.

Block 3: Management Practices

UNIT I: Stress Mitigation and Integrated Approaches: Strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, total quality management(TQM) - Current topics.

CROPS:

Aonla, Annonas, ber, bael, jamun, date palm, cactus pear, khejri, kair, pilu, lasoda, manila, tamarind, monkey jack, mahua, khirni, amra, seabuckthorn, chilgoza, cafel, rhododendron, box myrtle, chironji, phalsa, karonda,woodapple, paniala and other minor fruits of regional importance

RESOURCES

Krishna, H. and Sharma, R.R. 2017. *Fruit Production - Minor Fruits.*Daya Publishing House,Delhi.
Hiwale, S. 2015. *Sustainable Horticulture in Semiarid Drylands.* Springer.
More, T. A. Singh, R. S. Bhargava, R. and Sharma, B. D. 2012. *Arid Horticulture forNutrition and Livelihood.* Agrotech Publishing Academy, Udaipur (Rajasthan).
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, N. Delhi. Saroj, P. L., Dhandar, D. G. and Vashishta, B. B. 2004. *Advances in Arid Horticulture*, Vol.-1 *Present Status*. IBDC, Lucknow.
Saroj, P. L. and Awasthi, O. P. 2005. *Advances in Arid Horticulture*, Vol: II: *Production Technology of Arid and Semiarid Fruits*. IBDC, Lucknow.
Sontakke, M. B. 2014. *Production and Management of Fruit crops in Arid/ Drylands.*Agrotech Publishing Academy, Udaipur (Rajasthan).

FSC-622 ABIOTIC STRESS MANAGEMENT IN FRUIT CROPS (2+1)

THEORY

Block 1: Introduction

UNIT I: Basic Aspects and Principles: Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.).Pollution - increased level of CO_2, industrial wastes, impact of stress in fruit crop production, stress indices, physiological and biochemical factors associated with stress, fruit crops suitable for different stress situations.

Block 2: Stress Impact

UNIT I: Assessment, Physiology and Performance: Crop modeling for stress situations, cropping

systems, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stresses and their impact on crop growth and productivity.

Block 3: Stress Management

UNIT I: Mitigation Measures and Conservation Practices: Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers. Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, stability and sustainability indices.

PRACTICALS

1. Seed treatment /hardening practices (2)
2. Container seedling production(2)
3. Analysis of soil moisture estimates (FC, ASM, PWP) (1)
4. Analysis of plant stress factors, RWC, chlorophyll flourosence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate etc. under varied stress situations(5)
5. Biological efficiencies, WUE, solar energy conversion and efficiency(2)
6. Crop growth sustainability indices and economics of stress management(2)
7. Visit to orchards and watershed locations(2)

RESOURCES

Blumm, A. 1988. *Plant Breeding for Stress Environments*. CRC Publication, USA. Christiansen, M.N. and Lewis, C.F. 1982. *Breeding Plants for Less Favourable Environments.* Wiley International Science, USA.

Kanayama, Y. And Kochetor. 2015. *Abiotic Stress Biology in Horticultural Plants.* Springer. Kramer, P.J., 1980. *Drought Stress and the Origin of Adaptation*. In: *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons, USA.

Maloo, S.R. 2003. *Abiotic Stress and Crop Productivity*. AgrotechPubl.Academy, India. Nickell, L.G. 1983. *Plant Growth Regulating Chemicals*. CRC Publication, USA.

Rao. N.K.S., Shivashankar, K.S. and Laxman, R.H. 2016. *Abiotic Stress Physiology of Horticultural Crops.* Springer.

Turner, N.C. and Kramer, P.J. 1980. *Adaptation of Plants to Water and High TemperatureStress*. John Wiley & Sons, USA.

FSC-623 BIODIVERSITY AND CONSERVATION OF FRUIT CROPS (2+1)

THEORY

Block 1: GENERAL ASPECTS

UNIT I: Issues, Goals and Current Status: Biodiversity and conservation; issues and goals- needs and challenges; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/database of fruit crops in India

Block 2: Germplasm Conservation

UNIT I: Collection, Maintenance and Characterization: Exploration and collection of germplasm; sampling frequencies ; size and forms of fruit and nut germplasm collections; active and base collections.Germplasm conservation- *in situ* and *ex situ* strategies, on farm conservation; problem of recalcitrancy- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

Block 3: Regulatory Horticulture

UNIT I: Germplasm Exchange, Quarantine and Intellectual Property Rights: Regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phyto- sanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV&FR Act.

GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India.

PRACTICALS

1. Documentation of germplasm- maintenance of passport data and other records of accessions (2)
2. Field exploration trips and sampling procedures(2)
3. Exercise on *ex situ* conservation – cold storage, pollen/seed storage(2)
4. Cryopreservation(2)
5. Visits to National Gene Bank and other centers of PGR activities(2)
6. Detection of genetic constitution of germplasm(2)
7. Germplasm characterization using a standardised DUS test protocol(2)
8. Special tests with biochemical and molecular markers(2)

RESOURCES

Dhillon, B. S., Tyagi, R. K., Lal, A. and Saxena, S. 2004. *Plant Genetic Resource Management. – Horticultural Crops.*Narosa Publishing House, New Delhi.

Engles, J. M., Ramanath R, V., Brown, A. H. D. and Jackson, M. T. 2002. *Managing PlantGenetic Resources,* CABI, Wallingford, UK.

Frankel, O.H. and Hawkes, J.G., 1975. *Crop Genetic Resources for Today and Tomorrow*. Cambridge University Press, USA.

Hancock, J. 2012. *Plant Evolution and the Origin of Crops Species*. CAB International. Jackson, M., Ford-Lloyd, B. and Parry, M. 2014. *Plant Genetic Resources and Climate Change*. CABI, Wallingford, UK

Moore, J. N. and Ballington Jr, J. R. 1991. *Genetic Resources of Temperate Fruit and NutCrops.* ISHS, Belgium.

Peter, K.V.2008. *Biodiversity of Horticultural Crops*. Vol. II. Daya Publ. House, Delhi.

Peter,K.V.2011. *Biodiversity in HorticulturalCrops*.Vol.III. Daya Publ. House, Delhi.

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

Rajasekharan, P. E., Rao, V and Ramanatha, V. 2019. *Conservation and Utilization ofHorticultural Genetic Resources*. Springer.

Sthapit, B., et al. 2016. *Tropical Fruit Tree Diversity (Good Practices for in situ and ex situconservation)*. Bioversity International. Routledge, Taylor and Francis Group.

Virchow, D., 2012. *Conservation of Genetic Resources*, Springer Verlag, Berlin

FSC-624 SMART FRUIT PRODUCTION (2+0)

THEORY

Block 1: Introduction

UNIT I: Importance and Overview: Introduction and importance; concepts and applicationsof artificial intelligence systems; case studies in horticulture

Block 2: Crop Modelling and Forecasting

UNIT I: GIS, Sensors and Wireless Systems: Application of sensors in fruit production, crop monitoring – crop load and stress incidence forecast modules, remote sensing, Geographical Information System (GIS), Differential Geo-Positioning System (DGPS) hi-tech nursery production of fruit crops under protected conditions, ultra modern wireless based drip irrigation network,

Block 3: Nanotechnology

UNIT I: Concepts and Methods: Nanotechnology for smart nutrient delivery in fruit farming, concepts and methods, practical utility, nano-fertilizers, nano-herbicides; nano-pesticides

Block 4: Innovative Approaches

UNIT I: Mechanization, Automation and Robotics: Production systems amenable to automation and mechanization; automated protected structures (turn-key systems);hydroponics, aeroponics, bioreactors for large scale plant multiplication; Use of drones and robotics in fruit growing – robotic planters, sprayers, shakers, harvesters, stackers etc. Visit to Hi-tech facilities.

RESOURCES

Chadha *et al.* 2017. *Doubling Farmers Incomes through Horticulture*. Daya PublishingHouse, New Delhi.

Chadha *et al.* 2019.*Shaping the Future of Horticulture*. Kruger Brentt Publishers, UK.

Hewett, E. W. 2013. *Automation, Mechanization and Robotics in Horticulture*. *In:* Workshopon Emerging Postharvest Technologies. UC, Davis, USA.

http://horticulture.ucdavis.edu- Innovative Technology for Horticultural Department. Prasad, S., Singh, D. and Bhardwaj, R. L. 2012. *Hi-Tech Horticulture.*Agrobios (India).

Peter, K. V. 2016. *Innovations in Horticulture*. NIPA, New Delhi. Tyagi, S. 2019.

Hi- Tech Horticulture. Vols. 1 to 7. NIPA, New Delhi.

Zhang, Q. 2017. *Automation in Tree Fruit production – Principles and Practice*. CABI.