FACULTY OF AGRICULTURAL SCIENCES

ORDINANCE

Ph.D. Horticulture

(Fruit-Science)

SHREE GURU GOBIND SINGH TRICENTENARY UNIVERSITY
GURUGRAM (DELHI-NCR)

Preamble

(Fruit-Science)

India is one of the top-ranking fruit producing countries in the world. It is evident from current estimates that India is producing to the tune of 100 million metric tonnes on annual basis with average productivity of 14-15 tonnes per hectare. Diverse and peculiar agro-ecological conditions prevalent in the country lays down a suitable platform to grow wide range of tropical, subtropical and temperate fruits including nuts. Given the statistics, India is the largest producer of fruits like mango, banana, papaya and pomegranate achieving highest productivity in grape, banana and papaya on the global scenario. Several fruits like mango, banana, grapes, etc. are being exported besides several others have untapped export potential to earn foreign exchange. On the whole, horticulture contributes about 30 per cent to GDP of agriculture, with major contributions coming from cultivation and processing of fruits and nuts. It is worth mentioning that fruit production occupies a special role in today's multi-faceted agriculture.

Per capita consumption of fruits has increased significantly owing to consumer's awareness for healthy foods rich in vitamins, minerals and antioxidants coupled with enhanced levels of productivity leading to increased availability. Fruit production has witnessed tremendous developments owing to systematic research efforts in the past few decades. Notable examples are making available quality planting material including rootstocks through genetic improvement and efficient propagation protocols; judicious and integrated use of water and nutrients through micro-irrigation approaches; biotic and abiotic stress management practices; high density planting systems; crop regulation and pre- and post-harvest management.

The above mentioned wide-ranging advancements in the field of fruit science necessitate their precise inclusion in the course curricula for delivering and assuring quality education in an updated manner. This specifically aims to develop an especially trained cadre of human resource equipped with holistic and updated knowledge in fruit science. Thus, the various courses so developed constitute the State-of-Art framework of modern practices in fruit production and orchard management. The course design lays requisite emphasis on skill development in addition to addressing the educational requirements of the post-graduate students vis-a-vis latest know-how. Course contents have been framed to encompass various related fields like physiology, biochemistry, genetic and molecular biology to draw better insight and understanding into the different mechanisms underlying sustainable fruit production systems.

In short, course restructuring can be viewed as a comprehensive package drawing deeper insight into cultural and management practices extending from superior cultivars/ rootstocks, planting systems, propagation methods, training and pruning, orchard floor management, plant protection measures, crop regulation, maturation and harvesting. The existing courses have been redesigned to include the technological interventions, molecular approaches and hi-tech innovations made in the last decade or so. Courses have been added on Systematics, Nutrition, Research Ethics and Methodologies, Smart Fruit Production to broaden the student's reach of understanding of principles and modern trends in fruit growing.

Course Title with Credit Load
Ph.D. Horticulture (Fruit Science)

Course Code (ICAR pattern)	Course Code (SGTU pattern)	Course Title	Credits
FSC 601*	11100101	Innovative Approaches in Fruit Breeding	3(3+0)
FSC 602*	11100102	Modern Trends in Fruit Production	3(3+0)
FSC 603	11100103	Recent Developments in Growth Regulation	3(3+0)
FSC 604*	11100104	Advanced Laboratory Techniques	3(1+2)
FSC 605	11100106	Arid and Dry Land Fruit Production	2(2+0)
FSC 606	11100201	Abiotic Stress Management in Fruit Crops	3(2+1)
FSC 607	11100203	Biodiversity and Conservation of Fruit Crops	3(2+1)
FSC 608	11100205	Smart Fruit Production	3(2+0)
		Minor courses	06
		Supporting courses	05
FSC 691	11100206	Seminar-I	1(0+1)
FSC 692	11100301	Seminar-II	1(0+1)
FSC 699	11100319	Research	75(0+75)
		Total Credits	**100**

***** Compulsory among major course

Course Content

Course Title : Innovative Approaches in Fruit Breeding
Course Code : FSC 601 (11100101)
Credit Hours : 3(3+0)

Why this course?

Modern day fruit culture witnesses' rapid changes in production technologies and market trends. Ever changing environment and consumer preferences warrant constant development and adoption of genetically improved varieties. There is more thrust on novelty and distinctness in view of ever-increasing competition with enhanced emphasis on tailor made and trait specific designer varieties and rootstocks. The course is thus designed to integrate updated information on inherent breeding systems and innovative gene manipulation technologies enhancing breeding efficiency.

Aim of the course

To update knowledge on current trends and innovative approaches in fruit breeding.
The structural organization of the course is as under-

No.	Blocks	Units
1	Introduction	Current Trends and Status
2	Genetic Mechanisms	Inheritance Patterns and Breeding Systems
3	Breeding for Specific Traits	Plant Architecture, Stress Tolerance and Fruit Quality
4	Fast-Track Breeding	Transgenics, Markers and Genomics

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 fruit**s.**

Block 3: Breeding for Specific Traits

Unit I: Plant Architecture, Stress Tolerance and Fruit Quality: Recent advances in crop improvement efforts- wider adaptation, plant architecture, amenability to mechanization, fruit quality attributes, stress tolerance, crop specific traits; use of apomixis, gene introgression and 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 and breeding (MAS and MAB), use of genomics and gene editing technologies

Crops

Mango, banana, guava, papaya, Citrus, grapes, pomegranate, litchi, apple, pear, strawberry, kiwifruit, plums, peaches, apricot, cherries, nectarines, nut crops

Teaching Methods/ Activities

• Classroom Lectures
• Student Seminars/ Presentations
• Field Tours/ Demonstrations
• Assignments

Learning outcome

On successful completion of the course, the students are expected to
• Develop updated knowledge on current breeding objectives and trends
• Equip with information on innovative approaches enhancing breeding efficiency

Suggested Reading

- Al-Khayari J, Jain SN and Johnson DV. 2018. Advances in Plant Breeding Strategies. Vol. 3: Fruits. Springer.
- Badenes S and Byrne DH. 2012. Fruit Breeding. Springer.
- Hancock JF. 2008. Temperate Fruit Crop Breeding: Germplasm to Genomics. Springer.
- Kole C and Abbott AG. 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 SN and Priyadarshan PM. 2009. Breeding Plantation and Tree Crops: Tropical Species; Temperate Species. Springer -Verlag.
- Janick J and Moore JN, 1996. Fruit Breeding. Vols.I-III. John Wiley & Sons, USA.
- Orton T. 2019. Methods in Fruit Breeding. Elsevier.
- Singh SK, Patel VB, Goswami AK, Prakash J and Kumar C. 2019. Breeding of Perennial Horticultural Crops. Biotech Books. Delhi Sharma KK and Singh NP. 2011. Soil and Orchard Management. Daya Publishing House, New Delhi.
- Valavi SG, Peter KV and Thottappilly G. 2011. The Jackfruit. Stadium Press, USA.

Course Title : Modern Trends in Fruit Production
Course Code : FSC 602 (11100102)
Credit Hours : 3(3+0)

Why this course?

Agro-climatic diversity in India facilitates growing a wide range of fruits extending from tropical to subtropical to temperate fruits and nuts. To highlight their ecological specificities, seasonal variations and pertinent cultural practices, a course is designed exclusively for subtropical and temperate fruits.

Aim of the course

To keep abreast with latest developments and trends in production technologies of tropical, subtropical, and temperate fruits.

The course structure is as follows: -

No.	Blocks	Units
1	Introduction	General Concepts and Current Scenario
2	Advanced Technologies	Propagation, Planting Systems and Crop Regulation
3	Management Practices	Overcoming Stress and Integrated Approaches

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.

Teaching Methods/ Activities

- Class room Lectures
- Student Seminars/ Presentations
- Field Tours/ Demonstrations
- Assignments

Learning outcome

After the successful completion of the course, the students would have

- Updated knowledge on current trends in fruit production.

IX. Suggested Reading

- Bartholomew DP, Paull RE and Rohrbach KG. eds. 2002. The Pineapple: Botany, Production, and Uses. CAB International.
- Bose TK, Mitra SK and Sanyol D. Eds. 2002. Fruits of India – Tropical and Sub- Tropical. 3rd Ed. Vols. I, II. Naya Udyog, Kolkata, India.
- Dhillon WS and Bhatt ZA. 2011. Fruit Tree Physiology. Narendra Publishing House, New Delhi.
- Dhillon WS. 2013. Fruit Production in India. Narendra Publishing House, New Delhi.
- Gowen S. 1995. Bananas and Plantains. Chapman & Hall Publication, US.
- Litz RE. ed. 2009. The Mango: Botany, Production and Uses. CAB International.
- Peter KV. 2016. Innovations in Horticulture. NIPA, New Delhi.
- Robinson JC and Saúco VG. 2010. Bananas and Plantains (Vol. 19). CAB International.
- Samson JA. 1980. Tropical Fruits. Longman, USA.
- Sharma RR and Krishna H. 2014. Fruit Production: Major Fruits. Daya Publishing House, Delhi.
- Singh S, Shivankar VJ, Srivastava AK and Singh IP. 2004. Advances in Citriculture. Jagmander Book Agency, New Delhi.
- Stover RH and Simmonds NW. 1991. Bananas. Longman, USA.
- Chadha KL, Ahmed N, Singh SK and Kalia P. 2016. Temperate Fruits and Nuts- Way Forward for Enhancing Production and Quality. Daya Publishing House, New Delhi.
- Childers NF, Morris JR and Sibbett GS. 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 NE 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 AS and Wertheim SJ. 2005. Fundamentals of Temperate Zone Tree Fruit Production. Backhuys Publishers, Lieden, The Netherlands.
- Westwood MN. 2009. Temperate Zone Pomology: Physiology and Culture. 3rdEdn. Timber Press, USA.

Course Title : Recent Developments in Growth Regulation

Course Code : FSC 603 (11100103)
Credit Hours : 3(3+0)

Why this course?

Technological advancements have resulted in deeper understanding of growth and developmental processes in plants. There is equal and just need to apply these in fruit crops for harnessing maximum benefits in term of yield and quality. So, a course has been designed to provide latest information on physiological and biochemical aspects of growth and development.

Aim of the course

To develop updates on recent advances in growth regulation of fruit crops.

Structure of the course is as under:

No.	Blocks	Units
1	Introduction	Current Concepts and Principles
2	Growth Substances	Phytohormones and Growth Regulators
3	Growth and Development	Regulation of Developmental Processes

Theory

Block 1: Introduction

Unit 1: Current Concepts and Principles: Eco-physiological influences on growth and development of fruit crops-flowering, fruit set- Crop load and assimilate partitioning and distribution.

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.

Teaching Methods/ Activities

- Class room Lectures
- Student Seminars/ Presentations
- Field Tours/ Demonstrations
- Assignments

Learning outcome

After the successful completion of the course, the students would have

- Complete understanding of growth dynamics in various fruit crops
- Know-how on manipulation of growth and development processes.

Suggested Reading

- 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 of Plants. John Wiley & Sons, US.
- Fosket DE. 1994. Plant Growth and Development: A Molecular Approach. Academic Press, USA.
- Leopold AC and Kriedermann PE. 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 FB and Ross CW. 1992. Plant Physiology. 4th Ed. Wadsworth Publication.

Course Title : Advanced Laboratory Techniques
Course Code : FSC 604 (11100104)
Credit Hours : 3(1+2)

Why this course?

Accurate quality analysis of edible fruit commodities warrants stringent measurement protocols besides requisite instruments/ tools and laboratory facilities. Consequently, a specialized course is designed for imparting basic and applied training on physical and biochemical assessment of the horticultural produce.

Aim of the course

To familiarize with the laboratory techniques for analysis of fruit crops.
The organization of the course is as under:-

No.	Blocks	Units
1	General Aspects	I Safety Measures and Laboratory Maintenance
2	Qualitative and Quantitative Analysis	I Destructive and Non-destructive Analysis Methods
		II Chromatographic and microscopic Analysis
		III Sensory Analysis

Theory

Block 1: General Aspects

Unit I: 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 starch in 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 index of 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 of test rooms, products and panel.

VII. 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, sugars and 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)

Teaching Methods/ Activities

- Class room Lectures
- Laboratory/ Field Practicals
- Student Seminars/ Presentations
- Field Tours/ Demonstrations
- Assignments

Learning outcome

The students would be expected to develop skills and expertise on:

- Upkeep of laboratories and handling of research instruments
- Principles and methods of various analysis

Suggested Reading

- 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.
- Leo ML. 2004. Handbook of Food Analysis. 2nd Ed. Vols. I-III, USA.
- Linskens HF and Jackson JF. 1995. Fruit Analysis. Springer.
- Pomrenz Y and Meloan CE. 1996. Food Analysis – Theory and 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 AK. 1995. Post Harvest Technology of Fruits and Vegetables. Blackwell Sciences. USA.

Course Title : Arid and Dryland Fruit Production
Course Code : FSC 605 (11100106)
Credit Hours : 2(2+0)
Why this course?

Arid and dryland regions are known for growing an array of delicious and nutritious fruits (e.g. date palm, aonla, ber etc). Over the years, notable progress has been made in respect of domestication and technological advancements. Thus, a course has been developed.

Aim of the course

To keep abreast with latest developments and trends in production technology of arid and dryland fruit crops.

The course is organised as under:-

No.	Blocks	Units
1	Introduction	General Concepts and Current Scenario
2	Advanced Technologies	Propagation, Planting Systems and Crop Regulation
3	Management Practices	Stress Mitigation and Integrated Approaches

Theory

Block 1: Introduction

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

Teaching Methods/ Activities

- Class room Lectures
- Student Seminars/ Presentations
- Field Tours/ Demonstrations
- Assignments

Learning outcome

Consequent upon successful completion of the course, the students are expected to learnt about

- Fruit crops adopting to arid and drylands and their features
- Specific cultivation and management practices

Suggested Reading

- Hiwale S. 2015. Sustainable Horticulture in Semiarid Drylands. Springer.
- Krishna H and Sharma RR. 2017. Fruit Production – Minor Fruits.Daya Publishing House, Delhi.
- More T A, Singh RS, Bhargava R and Sharma BD. 2012. Arid Horticulture for Nutrition and Livelihood. Agrotech Publishing Academy, Udaipur (Rajasthan).

- Pareek OP, Sharma S and Arora RK. 2007. Underutilised Edible Fruits and Nuts, IPGRI, Rome.
- Peter K.V. 2010. Underutilized and Underexploited Horticultural Crops. NIPA, New Delhi.
- Saroj PL, Dhandar DG and Vashishta BB. 2004. Advances in Arid Horticulture, Vol.-1 Present Status. IBDC, Lucknow.
- Saroj P L and Awasthi OP. 2005. Advances in Arid Horticulture, Vol: II: Production Technology of Arid and Semiarid Fruits. IBDC, Lucknow.
- Sontakke MB. 2014. Production and Management of Fruit crops in Arid/ Drylands. Agrotech Publishing Academy, Udaipur (Rajasthan).

Course Title : Abiotic Stress Management in Fruit Crops
Course Code : FSC 606 (11100201)
Credit Hours : 3(2+1)

Why this course?

Low soil fertility coupled with unpredictable and unfavourable environments often result in stress conditions. Non-availability of optimum level of inputs and congenial weather necessitates the development of suitable management practices to overcome various abiotic stresses. Hence a course is customized.

Aim of the course

To updates knowledge on recent trends in management of abiotic stresses in fruit crops.
The course is organised as follows:

No.	Blocks	Units
1	Introduction	Basic Aspects and Principles
2	Stress Impact	Assessment, Physiology and Performance
3	Stress Management	Mitigation Measures and Conservation Practices

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 CO2, 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.

Practical

- Seed treatment/ hardening practices (2);
- Container seedling production (2);
- Analysis of soil moisture estimates (FC, ASM, PWP) (1);
- 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);
- Biological efficiencies, WUE, solar energy conversion and efficiency (2);
- Crop growth sustainability indices and economics of stress management (2);
- Visit to orchards and watershed locations (2);

Teaching Methods/ Activities

- Class room Lectures
- Laboratory/ Field Practicals
- Student Seminars/ Presentations
- Field Tours/ Demonstrations
- Assignments

Learning outcome

On successful completion of the course, the students are expected to generate know-how on

- Various types of abiotic stresses and their effects
- Physiological processes underlying abiotic stresses
- Management and conservation practices to overcome stress

Suggested Reading

- Blumm A. 1988. Plant Breeding for Stress Environments. CRC Publication, USA. Christiansen,
- MN and Lewis CF. 1982. Breeding Plants for Less Favourable Environments. Wiley International Science, USA.
- Kanayama Y and Kochetor. 2015. Abiotic Stress Biology in Horticultural Plants. Springer.
- Kramer PJ. 1980. Drought Stress and the Origin of Adaptation. In: Adaptation of Plants to
- Water and High Temperature Stress. John Wiley & Sons, USA.
- Maloo SR. 2003. Abiotic Stress and Crop Productivity. Agrotech Publ. Academy, India.
- Nickell LG. 1983. Plant Growth Regulating Chemicals. CRC Publication, USA.
- Rao NKS, Shivashankar KS and Laxman RH. 2016. Abiotic Stress Physiology of Horticultural Crops. Springer.
- Turner NC and Kramer PJ. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons, USA.

Course Title : Biodiversity and Conservation of Fruit Crops
Course Code : FSC 607 (11100203)
Credit Hours : 3(2+1)

Why this course?

The availability of pertinent gene pool is of utmost importance to mitigate adverse climate and to counter diseases and pests. In addition, specific gene sources (germplasm) would always be a necessity to develop superior genotypes. Considering the importance of conserving biodiversity in fruit crops for future use, the course has been designed.

Aim of the course

To understand the status and magnitude of biodiversity and strategies in germplasm conservation

of fruit crops.
The course is organised as follows: -

No.	Blocks	Units
1	General Aspects	Issues, Goals and Current Status
2	Germplasm Conservation	Collection, Maintenance and Characterization
3	Regulatory Horticulture	Germplasm Exchange, Quarantine and Intellectual Property Rights

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 and 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.

Practical

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

Teaching Methods/ Activities

- Class room Lectures
- Laboratory/ Field Practicals
- Student Seminars/ Presentations
- Field Tours/ Demonstrations
- Assignments

Learning outcome

The student would be expected to learn about the significance of germplasm and various strategies to conserve it in the present context.

Suggested Reading

- Dhillon BS, Tyagi RK, Lal A and Saxena S. 2004. Plant Genetic Resource Management. – Horticultural Crops.Narosa Publishing House, New Delhi.
- Engles JM, Ramanath RV, Brown AHD and Jackson MT. 2002. Managing Plant Genetic Resources, CABI, Wallingford, UK.
- Frankel OH and Hawkes JG. 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 JN and Ballington Jr, JR. 1991. Genetic Resources of Temperate Fruit and Nut Crops. ISHS, Belgium.
- Peter KV. 2008. Biodiversity of Horticultural Crops. Vol. II. Daya Publ. House, Delhi.
- Peter KV. 2011. Biodiversity in HorticulturalCrops.Vol.III. Daya Publ. House, Delhi.
- Rana JC and Verma VD. 2011. Genetic Resources of Temperate Minor Fruits (Indigenous and Exotic). NBPGR, New Delhi.
- Rajasekharan PE, Rao V and Ramanatha V. 2019. Conservation and Utilization of Horticultural Genetic Resources. Springer.
- Sthapit B, et al. 2016. Tropical Fruit Tree Diversity (Good Practices for in situ and ex situ conservation). Bioversity International. Routledge, Taylor and Francis Group.
- Virchow D. 2012. Conservation of Genetic Resources, Springer Verlag, Berlin.

Course Title : Smart Fruit Production
Course Code : FSC 608 (11100205)
Credit Hours : 2(2+0)

Why this course?

In the era of automation and mechanization, several recent innovations have direct applications in fruit growing. Thus a need is felt to have course on smart innovations.

Aim of the course

To acquire knowledge on hi-tech innovations useful in fruit crops.

The course is structure is as under:

No.	Blocks	Units
1	Introduction	Importance and Overview
2	Crop Modelling and Forecasting	GIS, Sensors and Wireless System
3	Nanotechnology	Concepts and Methods
4	Innovative Approaches	Mechanization, Automation and Robotics

Theory

Block 1: Introduction

Unit I: Importance and Overview: Introduction and importance; concepts and applications of 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.

Teaching Methods/ Activities

- Class room Lectures
- Student Seminars/ Presentations
- Field Tours/ Demonstrations
- Assignments

Learning outcome

After successful completion of the course, the students would be expected to

- Know the importance and various types of nutrients and their uptake mechanisms
- Analyse soil and plant status with respect to various nutrients
- Make use of corrective measures to overcome deficiency or toxicity

Suggested Reading

- Chadha et al. 2017. Doubling Farmers Incomes through Horticulture. Daya Publishing House, New Delhi.
- Chadha et al. 2019.Shaping the Future of Horticulture. Kruger Brentt Publishers, UK.
- Hewett EW. 2013. Automation, Mechanization and Robotics in Horticulture. In: Workshop on Emerging Postharvest Technologies. UC, Davis, USA.
- Peter KV. 2016. Innovations in Horticulture. NIPA, New Delhi.
- Prasad S, Singh D and Bhardwaj RL. 2012. Hi-Tech Horticulture. Agrobios (India).
- 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.
- http://horticulture.ucdavis.edu- Innovative Technology for Horticultural Department.

Selected Journals

Sr. No.	Name of the Journal	ISSN No.
1	Advances in Horticultural Science	0394-6169
2	*Acta Horticulturae*	0567-7572
3	American Journal of Enology and Viticulture	0002-9254
4	Annals of Arid Zone	0570-1791
5	Annals of Horticulture	0974-8784
6	Current Horticulture	2347-7377
7	Biodiversity and Conservation	0960-3115

8	European Journal of Horticultural Science (Gartenbauwissenschaft)	1611-4426
9	Fruits	0248-1294
10	Genetic Resources and Crop Evolution	0925-9864
11	Horticultural Plant Journal	2488-0141
12	Horticulture Environment and Biotechnology	2211-3452
13	Hort Science	0018-5345
14	Indian Journal of Arid Horticulture	Naas-1234
15	Indian Horticulture Journal	2249-6823
16	Indian Journal of Dryland Agricultural Research and Development	0971-2062
17	Journal of Horticulture	0972-8538
18	International Journal of Fruit Science	1553-8621
19	International Journal of Horticulture	1927-5803
20	International Journal of Innovative Horticulture	2320-0286
21	Journal of Applied Horticulture	0972-1045
22	Journal of Horticultural Research	2300-5009
23	Journal of Horticultural Science and Biotechnology (Journal of Horticultural Science, England)	1462-0316
24	Journal of Horticultural Sciences	0973-354X
25	Journal of Horticulture	2376-0354
26	Journal of The American Society for Horticultural Science	0003-1062
27	Journal of Tree Fruit Production	1055-1387
28	New Zealand Journal of Crop and Horticultural Science	0114-0671
29	Progressive Horticulture	0970-3020
30	*Scientia Horticulturae*	0304-4238
31	The Asian Journal of Horticulture	0973-4767
32	The Journal of American Pomological Society	1527-3741