Ph.D. Syllabus of Fruit Science department

Semester-I

I. Course Title : Innovative Approaches in Fruit Breeding

II. Course Code : FSC 601

III. Credit Hours : (3+0)

IV. 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.

V. Aim of the course

To update knowledge on current trends and innovative approaches in fruit breeding.

The structural organisation 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	Plant Architecture, Stress Tolerance and Fruit
4	Fast-Track Breeding	Transgenics, Markers and Genomics

VI. 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 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.

VII. Teaching Methods/ Activities

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

VIII. 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

IX. 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.

I. Course Title : Modern Trends in Fruit Production

II. Course Code : FSC 602

III. Credit Hours : (3+0)

IV. Why this course ?

Recent technological developments in propagation and cultural practices paves the way to grow fruit crops in an intensive and mechanised mode. As such a course has been developed to provide latest knowledge and updated account of modern production systems enhancing overall productivity.

V. 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	Propagation, Planting Systems and Crop Regulation
3	Management Practices	Overcoming Stress and Integrated Approaches

VI. 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.

VII. Teaching Methods/ Activities

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

VIII. 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.

I. Course Title : Recent Developments in Growth Regulation

II. Course Code : FSC 603

III. Credit Hours : (3+0)

IV. 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.

V. Aim of the course

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

Structure of the course is as under:

N	Blocks	Units
1	Introduction	Current Concepts and Principles
2	Growth Substances	Phytohormones and Growth Regulators
3	Growth and Development	Regulation of Developmental Processes

VI. 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 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 Horticultural Sciences–Fruit Science 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.

VII. Teaching Methods/ Activities

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

VIII. 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.

IX. 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.

I. Course Title : Advanced Laboratory Techniques

II. Course Code : FSC 604

III. Credit Hours : (1+2)

IV. Why this course ?

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

V. Aim of the course

To familiarize with the laboratory techniques for analysis of fruit crops.

The organisation of the course is as under:-

N	Blocks	Units
1	General Aspects	I Safety Measures and Laboratory
2	Qualitative and Quantitative Analysis	I Destructive and Non-destructive Methods Analysis Methods
		II Chromatographic and microscopic Analysis
		III Sensory Analysis

VI. 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 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. Practical

- 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)

VIII. Teaching Methods/ Activities

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

IX. 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

X. 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

Semester-II

I. Course Title : Arid and Dry land Fruit Production

II. Course Code : FSC 605

III. Credit Hours : (2+0)

IV. 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.

V. 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	Propagation, Planting Systems and Crop
3	Management	Stress Mitigation and Integrated Approaches

VI. 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, and 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

VII. Teaching Methods/ Activities

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

VIII. 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

IX. 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/ Dry lands. Agrotech Publishing Academy, Udaipur (Rajasthan).

I. Course Title : Abiotic Stress Management in Fruit Crops

II. Course Code : FSC 606

III. Credit Hours : (2+1)

IV. 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.

V. 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

VI. 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.

VII. 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);

VIII. Teaching Methods/ Activities

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

XI. 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

X. 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.

I. Course Title : Biodiversity and Conservation of Fruit Crops

II. Course Code : FSC 607

III. Credit Hours : (2+1)

IV. 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.

V. 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:-

N	Blocks	Units
1	General Aspects	Issues, Goals and Current Status
2	Germplasm Conservation	Collection, Maintenance and Characterization
3	Regulatory	Germplasm Exchange, Quarantine and

VI. 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.

VII. 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).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

X. 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.

I. Course Title : Smart Fruit Production

II. Course Code : FSC 608

III. Credit Hours : (2+0)

IV. 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.

V. Aim of the course

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

The course is structure is as under:

N	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

VI. 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 (turnkey 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.

VII. Teaching Methods/ Activities

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

VIII. Learning outcome

After successful completion of the course, the students are expected to learn about latest innovations in automation, nanotechnology and robotics for realising smart fruit production.

IX. 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.