SCHEME & SYLLABUS
Ph.D. (Hort.) in Fruit Science
Programme Code: PHD0015

Department of Agriculture
University Institute of Agriculture
Sant Baba Bhag Singh University

2025

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

Course Code	Course Title	Credit Hours
AGR925*	Innovative Approaches in Fruit Breeding	3+0
AGR927*	Modern Trends in Fruit Production	3+0
AGR929	Recent Developments in Growth Regulation	3+0
AGR931	Arid and Dry Land Fruit Production	2+0
AGR926	Advanced Laboratory Techniques	1+2
AGR928	Biodiversity and Conservation of Fruit Crops	2+1
AGR930	Abiotic Stress Management in Fruit Crops	2+1
AGR932	Smart Fruit Production	2+0
AGR933	Seminar-I	0+1
AGR934	Seminar-II	0+1
AGR935,936, 937,938,939 and 940	Research	0+75

*Indicates Core course for Ph.D.

Minimum Credit Requirements for Doctoral Programme

		Doctoral Programme
(i) Course work		
Major courses	:	12
Minor courses	:	06
Supporting courses	:	05
Seminar	:	02
(ii) Thesis Research	:	75
Total	:	100

Major courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken may be given *mark

Minor courses: From the subjects closely related to a student's major subject

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overall competence.

Scheme for Ph.D. (Hort.) Fruit Science

Semester-I

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR 925*	CR	Innovative Approaches in Fruit Breeding	3+0
2	AGR 927*	CR	Modern Trends in Fruit Production	3+0
3	AGR921	SC	Basic Sampling Techniques	2+1
4	AGR507	MC	Principles and Practices of Water Management	2+1
5	AGR935	RC	Research	0+5
			Total Credit Hours	17

Semester-II

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR 926	DSE	Advanced Laboratory Techniques	1+2
2	AGR 928	DSE	Biodiversity and Conservation of Fruit Crops	2+1
3	MAT529	SC	Experimental Designs	2+1
4	AGR502	MC	Principles and practices of soil fertility and nutrient management	2+1
5	AGR 936	RC	Research	0+5
			Total Credit Hours	17

Semester-III

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR933	DSE	Seminar-I	1+0
2	AGR 937	RC	Research	0+16
			Total Credit Hours	17

Semester-IV

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR934	DSE	Seminar-II	1+0
2	AGR 938	RC	Research	0+16
			Total Credit Hours	17

Semester-V

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR 939	RC	Research	0+16
			Total Credit Hours	16

Semester-VI

Sr. No	Subject Code	Type of Course	Subject Name	Credit Hours
1	AGR 940	RC	Research	0+16
			Total Credit Hours	16

- ***CR: Core Course, DSE: Discipline Specific Elective, MC: Minor Course, RC: Research Credit**

Course Contents
Ph.D. (Hort.) in Fruit Science

I. Course Title : Innovative Approaches in Fruit Breeding

II. Course Code : AGR925

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 Traits	Plant Architecture, Stress Tolerance and Fruit Quality
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).

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 tehnologies.

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 : AGR927

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.

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

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. 3rd Edn. Timber Press, USA.

I. Course Title : Recent Developments in Growth Regulation

II. Course Code : AGR929

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:

No.	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

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 : AGR926

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.

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

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)

- 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.

I. Course Title : Arid and Dryland Fruit Production

II. Course Code : AGR931

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 Technologies	Propagation, Planting Systems and Crop Regulation
3	Management Practices	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, national problems.

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/ Drylands. Agrotech Publishing Academy, Udaipur (Rajasthan).

I. Course Title : Abiotic Stress Management in Fruit Crops

II. Course Code : AGR930

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 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.

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);

- 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 : AGR928

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:-

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

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 and various 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 : AGR32

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:

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

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 (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.

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.

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.	Biodiversity and Conservation	0960-3115
7.	Current Horticulture	2347-7377
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.	HortScience	0018-5345
14.	Indian Horticulture Journal	2249-6823
15.	Indian Journal of Arid Horticulture	Naas-1234
16.	Indian Journal of Dryland Agricultural Research and Development	0971-2062

Sr. No.	Name of the Journal	ISSN No.
17.	Indian 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

I. Course Title: Principal and Practices of Soil Fertility and Nutrient Management

II. Course Code: AGR502

III. Credit Hours: 2+1

IV. Aim of the course

To impart knowledge of fertilizers and manures as sources of plant nutrients and apprise about the integrated approach of plant nutrition and sustainability of soil fertility.

V. Theory

Unit I

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

Unit II

Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Unit III

Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management. Soil less cultivation.

Unit IV

Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions.

Unit V

Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermincompost and residue wastes in crops.

VI. Practical

- Determination of soil pH and soil EC
- Determination of soil organic C
- Determination of available N, P, K and S of soil
- Determination of total N, P, K and S of soil
- Determination of total N, P, K, S in plant
- Computation of optimum and economic yield

I. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and class discussion

II. Learning outcome

Basic knowledge on soil fertility and management

III. Suggested Reading

- Brady NC and Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pearson Edu.
- Fageria NK, Baligar VC and Jones CA. 1991. Growth and Mineral Nutrition of Field Crops. Marcel Dekker.
- Havlin JL, Beaton JD, Tisdale SL and Nelson WL. 2006. Soil Fertility and Fertilizers. 7th Ed. Prentice Hall.
- Prasad R and Power JF. 1997. Soil Fertility Management for Sustainable Agriculture. CRC Press.
- Yawalkar KS, Agrawal JP and Bokde S. 2000. Manures and Fertilizers. Agri-Horti Publ.

I. Course Title: Principles and Practices of Water Management

II. Course Code: AGR507

III. Credit Hours: 2+1

IV. Aim of the course

To teach the principles of water management and practices to enhance the water productivity

V. Theory

Unit I

Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in of India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

Unit II

Field water cycle, water movement in soil and plants; transpiration; soil-water- plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and loses.

Unit III

Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses. Irrigation efficiency and water use efficiency.

Unit IV

Water management of crop and cropping system, Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement- estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

Unit V

Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

Unit VI

Quality of irrigation water and management of saline water for irrigation, water management in

problem soils

Unit VII

Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

Unit VIII Hydroponics, **Unit IX**

Water management of crops under climate change scenario.

VI. Practical

- Determination of Field capacity by field method
- Determination of Permanent Wilting Point by sunflower pot culture technique
- Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
- Determination of Hygroscopic Coefficient
- Determination of maximum water holding capacity of soil
- Measurement of matric potential using gauge and mercury type tensiometer
- Determination of soil-moisture characteristics curves
- Determination of saturated hydraulic conductivity by constant and falling head method
- Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
- Measurement of soil water diffusivity
- Estimation of unsaturated hydraulic conductivity
- Estimation of upward flux of water using tensiometer and from depth ground water table
- Determination of irrigation requirement of crops (calculations)
- Determination of effective rainfall (calculations)
- Determination of ET of crops by soil moisture depletion method16. Determination of water requirements of crops
- Measurement of irrigation water by volume and velocity-area method
- Measurement of irrigation water by measuring devices and calculation of irrigation efficiency
- Determination of infiltration rate by double ring infiltrometer

VII. Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment and field visit

VIII. Learning outcome

Basic knowledge on water management for optimization of crop yield

IX. Suggested Reading

- Majumdar DK. 2014. Irrigation Water Management: Principles and Practice. PHL Learning private publishers
- Mukund Joshi. 2013. A Text Book of Irrigation and Water Management Hardcover, Kalyani publishers
- Lenka D. 1999. Irrigation and Drainage. Kalyani.
- Michael AM. 1978. Irrigation: Theory and Practice. Vikas Publ.
- Paliwal KV. 1972. Irrigation with Saline Water. IARI Monograph, New Delhi.
- Panda SC. 2003. Principles and Practices of Water Management. Agrobios.
- Prihar SS and Sandhu BS. 1987. Irrigation of Food Crops - Principles and Practices. ICAR.
- Reddy SR. 2000. Principles of Crop Production. Kalyani.
- Singh Pratap and Maliwal PL. 2005. Technologies for Food Security and Sustainable Agriculture. Agrotech Publ.

I. Course Title : Basic Sampling Techniques

II. Course Code : AGR921

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of

survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

V. Theory

Unit I

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

Unit II

Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Unit III

Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

Unit IV

Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

VI. Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling.

VII. Suggested Reading

- Cochran WG. 1977. Sampling Techniques. John Wiley.
- Murthy MN. 1977. Sampling Theory and Methods. 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D, Singh P and Kumar P. 1982. Handbook on Sampling Methods. IASRI Publ.
- Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. Sampling Theory of Surveys with Applications. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Cochran WG. 2007. Sampling Techniques, 3rd Edition. John Wiley & Sons Publication

I. Course Title : Experimental Designs

II. Course Code: MAT529

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

V. Theory

Unit I

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

Unit II

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

Unit III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees

of freedom. Concept of confounding.

Unit IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of

results. Response surfaces. Combined analysis.

VI. Practical

• Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,

• Analysis with missing data,

• Split plot and strip plot designs.

VII. Suggested Reading

• Cochran WG and Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.

• Dean AM and Voss D. 1999. Design and Analysis of Experiments. Springer.

• Montgomery DC. 2012. Design and Analysis of Experiments, 8th Ed. John Wiley.

• Federer WT. 1985. Experimental Designs. MacMillan.

• Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.

• Nigam AK and Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. ASRI Publ.

• Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley.

• www.drs.icar.gov.in.

I. Course Title : Basic Sampling Techniques

II. Course Code : AGR921

III. Credit Hours : 2+1

IV. Aim of the course

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

V. Theory

Unit I

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

Unit II

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Unit III

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Unit IV

Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

VI. Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.;
- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling;
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- Estimation using multistage design, double sampling.

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- Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
- Singh D, Singh P and Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.
- Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- Cochran WG. 2007. *Sampling Techniques*, 3rd Edition. John Wiley & Sons Publication