SIKKIM UNIVERSITY

(A Central University Established by an Act of Parliament of India, 2007)

LEARNING OUTCOME - BASED CURRICULUM

DOCTORAL PROGRAMME IN HORTICULTURE

PhD (Horticulture)

(With effect from Academic Session 2023-24)

DEPARTMENT OF HORTICULTURE

SIKKIM UNIVERISTY

6TH MILE, TADONG - 737102

GANGTOK, SIKKIM, INDIA

PREAMBLE

PhD. Horticulture programme is envisaged in four specializations *viz.*, Fruit Science, Vegetable Science, Floriculture and Landscaping, and Plantation, Spices, Medicinal, and Aromatic Crops. The programme focuses on broadening the student's reach of understanding of principles and modern trends in Horticulture. Research Methodology, and Research and Publication Ethics are common courses for the School of Life Sciences. The departmental level courses focus on the courses that are to expose the students to current research trends in the subject. The PhD. coursework covers in two semesters.

PROGRAMME LEARNING OUTCOMES

PLO1: Knowledge

At the end of the programme, the students will be able to

1. Demonstrate thorough knowledge on the advances in management of fruit crops, vegetable crops, flower crops medicinal, aromatic and plantation crops.
2. Demonstrate thorough knowledge on biodiversity conservation and frontier aspects of biotechnology.
3. Discover, interpret, and communicate new knowledge through research papers, case studies which satisfies peer reviews.

PLO2: Cognitive skills

At the end of the programme the students will be able to:

1. Design and conduct their own research experiments.
2. Analyse data, interpret results and prepare reports on the research conducted.
3. Communicate effectively through written exam, reports, presentations and participate in discussions.
4. Design research projects in their respective domain of study.
5. Apply a significant range of advanced and specialised skills and be able to act autonomously in the planning and implementation of research.
6. Practice a proactive, self-critical, and self-reflective approach based on research and develop professional relationship.

PLO3: Interpersonal Skills and Responsibilities

At the end of the programme the students will be able to:

1. Participate and discuss with experts in workshops and seminars.
2. Organize and act as a coordinator between members of team.
3. Work constructively in groups.
4. Design their own research protocol based on available literature.

PLO4: Communication, Information Technology, Numerical

At the end of the programme the students will be able to:

1. Perform research work, collect data, prepare presentations, combine the knowledge and communicate effectively, analyse data and write dissertations.
2. Demonstrate communication skills such as writing, reading, presenting and debating.
3. Demonstrate skills in usage of computer, networks, software packages relevant to agriculture research analysis.

ORGANIZATION OF COURSE CONTENTS & CREDIT

REQUIREMENTS FOR PhD IN HORTICULTURE

Subject Heads	Credit allotted
Major	12
Minor	06
Supporting	06
Research Proposal and Doctoral Seminar	04
Research	75
Total Credits	**103**

Major courses: The subject in which the students want specialization.

Minor courses: The subject closely related to the student's major subject.

Supporting courses: The subject is not related to the major subject. It could be any subject considered relevant to the student's research work.

Research work: As per ICAR 5th Dean committee syllabus recommendation 75 credits for PhD thesis work is compulsory. These credits can be distributed over different semesters.

Code	Title of the Course	Credit	Semester
	Compulsory Supporting courses	**L+T+P**	
HOR-SU-600	Research Methodology	3+1+0	I
HOR-SU-690	Research & Publication Ethics	2+0+0	I
HOR-C-691	Research Proposal and Doctoral Seminar	0+0+4	II
HOR-R-699	Doctoral Research*	75	
	Comprehensive Examination**	0+0+0	III
	Fruit Science		
HOR-C-601	Innovative Approaches in Fruit Breeding	2+0+1	I
HOR-C-602	Modern Trends in Fruit Production	2+0+1	I
HOR-C-603	Biodiversity and Conservation of Fruit Crops	2+0+1	II
HOR-C-604	Abiotic Stress Management in Fruit Crops	2+0+1	II
	Vegetable Science		
HOR-C-611	Recent Trends in Vegetable Production	2+0+1	I
HOR-C-612	Advances in Breeding of Vegetable Crops	2+0+1	I
HOR-C-613	Biotechnological Approaches in Vegetable Crops	2+0+1	II
HOR-C-614	Abiotic Stress Management in Vegetable Crops	2+0+1	II
	Floriculture and Landscaping		
HOR-C-621	Crop Regulation in Ornamental Crops	2+0+1	I
HOR-C-622	Postharvest Biology of Floriculture Crops	2+0+1	I
HOR-C-623	Biotechnological Approaches in Floriculture Crops	2+0+1	II
HOR-C-624	Advances in Landscaping	2+0+1	II
	Plantation, Spices, Medicinal and Aromatic Crops		
HOR-C-631	Advances in Production of Plantation and Spice Crops	2+0+1	I
HOR-C-632	Advances in Production of Medicinal and Aromatic Crops	2+0+1	I
HOR-C-633	Biotechnological Approaches in PSMA Crops	2+0+1	II
HOR-C-634	Abiotic Stress Management in PSMA Crops	2+0+1	II

***Evaluation will be based on satisfactory/unsatisfactory reports of RAC and Research credits will be distributed over 3rd, 4th , 5th, and 6th semesters.**
**** Compulsory Comprehensive exam will be held at the beginning of the third semester. All students need to qualify the comprehensive exam. As per ICAR 5th Dean Commission recommendation, the comprehensive exam will be evaluated via Oral examination.**

Semester-wise credit distribution

Semester	Credits distribution
First	18 (Major 6 + Minor 6 + 6 Supporting)
Second	10 (Major 6 + 4 Research Proposal & Seminar)
Thesis Credits	75 (Distributed over the remaining semesters)
Total Credits	103

COURSES DETAIL

SUPPORTING COURSES

HOR-SU-600 RESEARCH METHODOLOGY (SCHOOL LEVEL)

Semester: First semester **Total Marks: 100**
L+T+P: 3+1+0 = 4 Credits **Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs**

COURSE LEARNING OUTCOMES
Students will be able to:
CLO1: Outline the field of research and different research methods.
CLO2: Comprehend the concepts of research problems, identification of research gap, framing research questions, and research designs.
CLO3: Apply modern statistical tools to address research problems, research design, and scientific document preparation.

UNIT I: RESEARCH DESIGN AND DATA COLLECTION
Research methodology: different types of research design, Sampling methods- procedures of sampling, criteria of selecting a sample, and different types of sampling designs. Primary and secondary data. Framing research questions and developing hypotheses.

UNIT II: PROCESSING AND ANALYSIS OF DATA
Processing operations: Elements/types of analysis, usefulness of statistics in research, dispersion, Correlation and regression analysis: Bivariate and multivariate correlation, concepts of linear and higher order regression, multivariate regression, regression models, Introduction to computer-based programming in data analysis such as R.

UNIT III: HYPOTHESES TESTING AND BIOSTATISTICS
Basic concepts of hypothesis testing, Parametric and Non-parametric tests, Normality tests, F and t-tests, Mann- Whitney U test, Chi square test, ANOVA (One Way and two way), MANOVA, ANCOVA, Kruskal-Wallis one way ANOVA, Ordination techniques: PCA, PCoA, CCA, NMDS.

UNIT IV: SCIENTIFIC WRITING
Types of scientific documents, guidelines for preparation of scientific articles/documents, identification of journals, referencing and reference management tools, Review articles: types of review (narrative, systematic and meta-analysis)

SUGGESTED TEACHING LEARNING STRATEGIES

- Lecture-cum discussion, library readings, critical discussion.
- Organizing philosophical debates and group discussions, case studies, projects.
- Individual presentations by student on selected topic.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of the CLO

SUGGESTED READINGS:

1. CSIR (2019). CSIR Guidelines for Ethics in Research and in Governance. Council of Scientific and Industrial Research, New Delhi.
2. Kothari, C.R. and Garg, G. (2019). Research Methodology. New Delhi: New Age International Publishers. 1-480. ISBN-13: 978-9386649225

HOR-SU-690 RESEARCH & PUBLICATION ETHICS

Semester: First semester **Total Marks: 100**
L+T+P: 2+0+0 = 2 Credits **Lecture: 30 Hrs + Tutorial: 0 Hrs + Practical: 0 Hrs**

COURSE LEARNING OUTCOME:

Students will be able to:

CLO1: Determine the ethics involved in research and be aware on moral values and standards in research.

CLO2: Record the details of publication ethics and scientific writing.

CLO3: Comprehend moral values and standards in research.

CLO4: Design their own research plan and infer the ethics involved in their research.

CLO5: Determine and follow ethical guidelines in human and animal experimentation.

CLO6: Recognize and use open-access publishing, databases, and learn research metrics

Unit I: SCIENTIFIC CONDUCT AND PUBLICATION ETHICS

Ethics with respect to science and research. Intellectual honesty and research integrity. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), Redundant publications: duplicate and overlapping publications, salami slicing. Selective reporting and misrepresentation of data. Best practices /Standards setting initiatives and guidelines: COPE, WAME, etc. Conflicts of interest. Violation of publication ethics, authorship, and contributorship. Identification of publication misconduct, complaints, and appeals. Predatory publishers and journals. Welfare of animals used in research, ethics in research involving human experimentation. Institutional ethical committee, Institutional animal ethics committee and Biosafety committee: roles and responsibilities.

Unit II: OPEN ACCESS PUBLISHING, DATABASES AND RESEARCH METRICS

Concept of Open Educational Resources (OER), concept of open license, open access publishing, open access content management

Databases: Indexing databases, Citation databases: Web of Science, Scopus, etc.

Research Metrics: Impact Factor of Journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score: Metrics: h-index, g index, i10 index, altmetrics, ISBN, ISSN

UGC CARE list journals, latest UGC regulations on academic integrity

SUGGESTED TEACHING LEARNING STRATEGIES

- Lecture-cum discussion, library readings, critical discussion.
- Organizing philosophical debates and group discussions, case studies, and projects.
- Individual presentation by student on selected topic.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
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Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

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SUGGESTED READINGS:

1. Bird, A. (2006). Philosophy of Science. Routledge Maclntyre,
2. Alasdair (1967) A Short History of Ethics. London
3. Chaddah, P.(2018) Ethics in Competitive Research: Do not get Scooped; do not get Plagiarized, ISBN :978-9387480865
4. National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). On Being a Scientist: A Guide to responsible conduct in Research: Third Edition, National Academies Press.
5. Resnik, DB.(2011) What is ethics in research & why is it important. National institute of Environmental Health Science, 1-10 Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm
6. Beall, J. (2012) Predatory publishers are corrupting open access. Nature, 489(7415), 179-179. https://doi.org/10.1038/489179a
7. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN:978-81-939482-1-7.htt://www.insaindia.res.in/pdf/Ethics_ Book.pdf.

FRUIT SCIENCE

SEMESTER-I

Code	Course Title	Type of Course	Credits
HOR-SU-600	Research Methodology	Supporting	3+1+0
HOR-SU-690	Research & Publication Ethics	Supporting	2+0+0
HOR-C-601	Innovative Approaches in Fruit Breeding	Major	2+0+1
HOR-C-602	Modern Trends in Fruit Production	Major	2+0+1
	HOR-C-611/621/631	Minor	2+0+1
	HOR-C-612/622/632	Minor	2+0+1
	Total		18

SEMESTER-II

Code	Course Title	Type of Course	Credits
HOR S 691	Research Proposal and Doctoral Seminar	Major	0+0+4
HOR-C-603	Biodiversity and Conservation of Fruit Crops	Major	2+0+1
HOR-C-604	Abiotic Stress Management in Fruit Crops	Major	2+0+1
	Total		10

HOR-C-601 INNOVATIVE APPROACHES IN FRUIT BREEDING

Semester: First semester **Total Marks: 100**

L+T+P: 2+0+1= 3 Credits **Lecture: 30 Hrs + Tutorial: 0 Hrs+ Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

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

THEORY

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.

Unit II

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

Unit III

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 IV

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

PRACTICAL

- Description and cataloguing of germplasm,
- Viability tests and germination tests
- survey and clonal selection,
- observations on pest, disease, and stress reactions in inbred and hybrids,
- use of metagenes and colchicine for inducing mutation and ploidy changes,
- practices in different methods of breeding fruit crops and
- *in-vitro* breeding techniques.
- DNA extraction and amplification

SUGGESTED TEACHING LEARNING STRATEGIES

- Lecture-cum discussion, library readings, critical discussion.
- Organizing philosophical debates and group discussions, case studies, and projects.
- Individual presentation by students on selected topics.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of the CLO

SUGGESTED READINGS

- 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

HOR-C-602 MODERN TRENDS IN FRUIT PRODUCTION

Semester: First semester **Total Marks: 100**

L+T+P: 2+0+1= 3 Credits **Lecture: 30 Hrs + Tutorial: 0 Hrs+ Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

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

CLO1: Updated knowledge on current trends in fruit production.

THEORY

Unit I

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

Unit II

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.

Unit III

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

Unit IV

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

PRACTICAL

- Survey of existing fruit cropping systems and development of a model cropping system,
- estimating nutrient deficiency,
- estimation of water use efficiency,
- soil test-crop response correlations,
- practices in plant growth regulation,
- studying physiological and biochemical responses,

- quality analysis.

SUGGESTED TEACHING LEARNING STRATEGIES

- Lecture-cum discussion, library readings, critical discussion.
- Organizing philosophical debates and group discussions, case studies, and projects.
- Individual presentation by students on selected topics.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of the CLO

SUGGESTED READINGS

- 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.

HOR-C-603 BIODIVERSITY AND CONSERVATION OF FRUIT CROPS

Semester: Second semester **Total Marks: 100**

L+T+P: 2+0+1= 3 Credits **Lecture: 30 Hrs + Tutorial: 0 Hrs+ Practical: 20 Hrs**

COURSE LEARNING OUTCOMES

The student would be expected to learn about

CLO1: the significance of germplasm and various strategies to conserve it in the present context.

THEORY

Unit I

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

Unit II

Collection, Maintenance, and Characterization: Exploration and collection ofgermplasm; 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.

Unit III

Germplasm Exchange, Quarantine and Intellectual Property Rights: Regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm, and maintenance of the core collection.

Unit IV

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;

- Field exploration trips and sampling procedures;
- Exercise on *ex-situ* conservation – cold storage, pollen/ seed storage;
- Cryopreservation;
- Visits to National Gene Bank and other centres of PGR activities;
- Detection of genetic constitution of germplasm;
- Germplasm characterization using a standardized DUS test protocol;
- Special tests with biochemical and molecular markers.

SUGGESTED TEACHING LEARNING STRATEGIES

- Lecture-cum discussion, library readings, critical discussion.
- Organizing debates and group discussions, case studies, and projects.
- Individual presentation by students on selected topics.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READINGS

- 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 Horticultural Crops.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). Biodiversity International. Routledge, Taylor and Francis Group.
- Virchow D. 2012. Conservation of Genetic Resources, Springer Verlag, Berlin

HOR-C-604 ABIOTIC STRESS MANAGEMENT IN FRUIT CROPS

Semester: Second semester **Total Marks: 100**

L+T+P: 2+0+1= 3 Credits **Lecture: 30 Hrs + Tutorial: 0 Hrs+ Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

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

CLO1: Various types of abiotic stresses and their effects

CLO2: Physiological processes underlying abiotic stresses

CLO3: Management and conservation practices to overcome stress

THEORY

Unit I

Basic Aspects and Principles: Stress – definition, classification, stress 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.

Unit II

Assessment, Physiology, and Performance: Crop modelling 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.

Unit III

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.

Unit IV

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

SUGGESTED TEACHING LEARNING STRATEGIES

- Lecture-cum discussion, library readings, critical discussion.
- Organizing debates and group discussions, case studies, and projects.
- Individual presentation by student on selected topic.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READINGS

- 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.

VEGETABLE SCIENCE

SEMESTER-I

Code	Course Title	Type of Course	Credits
HOR-SU-600	Research Methodology	Supporting	3+1+0
HOR-SU-690	Research & Publication Ethics	Supporting	2+0+0
HOR-C-611	Recent Trends in Vegetable Production	Major	2+0+1
HOR-C-612	Advances in Breeding of Vegetable Crops	Major	2+0+1
	HOR-C-601/621/631	Minor	2+0+1
	HOR-C-602/622/632	Minor	2+0+1
	Total		18

SEMESTER-II

Code	Course Title	Type of Course	Credits
HOR-C-691	Research Proposal and Doctoral Seminar	Major	0+0+4
HOR-C-613	Biotechnological Approaches in Vegetable Crops	Major	2+0+1
HOR-C-614	Abiotic Stress Management in Vegetable Crops	Major	2+0+1
	Total		10

HOR-C-611 RECENT TRENDS IN VEGETABLE PRODUCTION

Semester: First Semester **Total Marks: 100**

L+T+P: 2+0+1 = 3 **Credits Lecture: 30 Hrs + Tutorial: 0 Hrs + Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

After successful completion of this course, the students are exposed to:

CLO1: Acquire the knowledge about recent trends in production technology of vegetable crops

THEORY

Present status and prospects of vegetable cultivation; nutritional, antioxidant and medicinal values; climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/ disorders and correction methods; different cropping systems; mulching; Protected cultivation of vegetables, containerized culture for year round vegetable production; low cost polyhouse; nethouse production; crop modelling, organic gardening; vegetable production for pigments, export and processing of:

Unit I

Solanaceous crops: Tomato, brinjal, chilli, sweet pepper and potato.

Unit II

Cole crops: Cabbage, cauliflower and knol-khol, sprouting broccoli. Okra, onion, peas and beans, amaranth and drumstick.

Unit III

Root crops and cucurbits: Carrot, beet root, turnip and radish and cucurbits

Unit IV

Tuber crops: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.

PRACTICAL

- Seed hardening treatments;
- practices in indeterminate and determinate vegetable growing and organic gardening; portrays and ball culture;
- diagnosis of nutritional and physiological disorders;
- analysis of physiological factors like anatomy; photosynthesis; light intensity indifferent cropping situation;
- assessing nutrient status,
- use of plant growth regulators;
- practices in herbicide application;
- estimating water requirements in relation to crop growth stages,
- maturity indices; dry land techniques for rainfed vegetable production;
- vegetable waste recycling management;
- quality analysis; marketing survey of the above crops;
- visit to vegetable and fruit marketing and packinghouses.

SUGGESTED TEACHING LEARNING STRATEGIES

- Lecture-cum discussion, library readings, critical discussion.
- Organizing group discussions, case studies, and projects.
- Individual presentation by student on selected topic.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern Teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READINGS

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HOR-C-612 ADVANCES IN BREEDING OF VEGETABLE CROPS

Semester: First Semester **Total Marks: 100**

L+T+P: 2+0+1 = 3 **Credits Lecture: 30 Hrs + Tutorial: 0 Hrs + Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

After successful completion of this course, the students are exposed to:

CLO1: Breeding objectives and trends

CLO2: Recent advances in vegetable breeding

THEORY

Evolution, distribution, cytogenetics, Genetics and genetic resources, wild relatives, genetic divergence, hybridization, inheritance of qualitative and quantitative traits, heterosis breeding, plant idotype concept and selection indices, breeding mechanisms, pre breeding, mutation breeding, ploidy breeding, breeding for biotic and abiotic stresses, breeding techniques for improving quality and processing characters, biofortification, *in-vitro* breeding, marker assisted breeding, haploidy, development of transgenic.

Unit I

Solanaceous crops—Tomato, Brinjal, Hot Peeper, Sweet Pepper, Okra and Potato

Unit II

Cucurbits and Cole crops

Unit III

Legumes and leafy vegetables—Peas and Beans, Amaranth, Palak, Chenopods and Lettuce.

Unit IV

Root crops and onion—Carrot, Beetroot, Radish, Turnip, Onion

Tuber crops—Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea

PRACTICAL

- Designing of breeding experiments,
- screening techniques for abiotic stresses,
- screening and rating for pest, disease and nematode resistance,
- estimation of quality and processing characters,
- screening for quality improvement,
- estimation of heterosis and combining ability,

- induction and identification of mutants and polyploids,
- distant hybridization and embryo rescue techniques.

SUGGESTED TEACHING LEARNING STRATEGIES

- Lecture-cum discussion, library readings, critical discussion.
- Organizing group discussions, case studies, and projects.
- Individual presentation by student on selected topic.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READINGS

- Allard RW. 1999. Principle of plant breeding. John Willey and Sons, USA.
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HOR-C-613 BIOTECHNOLOGICAL APPROACHES IN VEGETABLE CROPS

Semester: Second semester **Total Marks: 100**

L+T+P: 2+0+1 = 3 **Credits Lecture: 30 Hrs + Tutorial: 0 Hrs + Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

The student would be expected to learn

CLO1: Different biotechnological tools

CLO2: NGS, genetic engineering

THEORY

Unit I

Importance and scope of biotechnology – in vegetable crop improvement. *In-vitro* culture, micropropagation, anther culture, pollen culture, ovule culture, embryo culture, endosperm culture. *Somatic embryogenesis* – somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion. Somatic hybrids and cybrids and their application in vegetable improvement programme.

Unit II

Blotting techniques, DNA finger printing – Molecular markers/ DNA based markers and role. RFLP, AFLP, RAPD, SSR, SNPs, DNA probes. QTL mapping. MAS and its application in vegetable crop improvement. Allele mining by TILLING and Eco- TILLING.

Unit III

Plant genetic engineering – Scope and importance, Concepts of cisgenesis, intragenesis and transgenesis. Gene cloning, direct and indirect methods of gene transfer. Role of RNAi based gene silencing in vegetable crop improvement. Biosafety issue, regulatory issues for commercial approval.

Unit IV

Concepts and methods of next generation sequencing (NGS)- Genome sequencing, transcriptomics, proteomics, metabolomics. Genome editing (ZFN, TALENS and CRISPER)

CROPS

Solanaceous crops, cole crops, cucurbitaceous crops, root vegetables, garden pea, onion, potato and leafy vegetables

PRACTICAL

- Micropropagation, Pollen- Ovule and Embryo culture- Synthetic seed production;
- *In-vitro* mutation induction, *in-vitro* rooting-hardening at primary and secondary nurseries;

- DNA isolation from economic vegetable crop varieties – Quantification and amplification;
- DNA and Protein profiling – molecular markers, PCR Handling;
- Vectors for cloning and particle bombardment;
- DNA fingerprinting of flower crop varieties;
- Project preparation for the establishment of low, medium, and high-cost tissue culture laboratories

SUGGESTED TEACHING LEARNING STRATEGIES

- Class room lectures
- Laboratory/ field practical
- Student seminars/ presentations
- Field tours/ demonstrations
- Assignments

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READINGS

- Bajaj YPS. (Ed.). 1987. Biotechnology in agriculture and forestry. Vol. XIX. Hitech and Micropropagation. Springer.
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- Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK and Mohanadas S. 2001. Biotechnology of horticultural crops. Vols. I-III. Naya Prokash.
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HOR-C-614 ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS

Semester: Second semester **Total Marks: 100**

L+T+P: 2+0+1 = 3 **Credits Lecture: 30 Hrs + Tutorial: 0 Hrs + Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

After successful completion of this course, the students are expected to:

CLO1: Acquire the knowledge about effect of different abiotic stresses on vegetables

CLO2: Methods to mitigate abiotic stress in vegetables

THEORY

Unit I

Environmental stress—its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.

Unit II

Mechanism and measurements—tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

Unit III

Soil-plant-water relations—under different stress conditions in vegetable crops production and their management practices.

Unit IV

Techniques of vegetable growing under water deficit, water logging, salinity, and sodicity. Use of chemicals—techniques of vegetable growing under high and low temperature conditions, use of chemicals and anti-transpirant in alleviation of different stresses.

PRACTICAL

- Identification of susceptibility and tolerance symptoms to various types of stress
- in vegetable crops;
- Measurement of tolerance to various stresses in vegetable crops;
- Short term experiments on growing vegetable under water deficit, water logging,
- salinity and sodicity, high and low temperature conditions;
- Use of chemicals for alleviation of different stresses.

SUGGESTED TEACHING LEARNING STRATEGIES

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedure
- Group discussion

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READINGS

- Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa Publ. House.
- Dwivedi P and Dwivedi RS. 2005. Physiology of abiotic stress in plants. Agrobios.
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- Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables volume II. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p.
- Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p.
- Ram HH. 2001. Vegetable breeding. Kalyani.
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FLORICULTURE AND LANDSCAPING

SEMESTER-I

Code	Course Title	Type of Course	Credits
HOR-SU-600	Research Methodology	Supporting	3+1+0
HOR-SU-690	Research & Publication Ethics	Supporting	2+0+0
HOR-C-621	Crop Regulation in Ornamental Crops	Major	2+0+1
HOR-C-622	Postharvest Biology of Floriculture Crops	Major	2+0+1
	HOR-C-601/611/631	Minor	2+0+1
	HOR-C-602/612/632	Minor	2+0+1
	Total		18

SEMESTER-II

Code	Course Title	Type of Course	Credits
HOR-C-691	Research Proposal and Doctoral Seminar	Major	0+0+4
HOR-C-623	Biotechnological Approaches in Floriculture Crops	Major	2+0+1
HOR-C-624	Advances in Landscaping	Major	2+0+1
	Total		10

HOR-C-621 CROP REGULATION IN ORNAMENTAL CROPS

Semester: First semester **Total Marks: 100**

L+T+P: 2+0+1= 3 Credits **Lecture: 30 Hrs + Tutorial: 0 Hrs+ Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

After successful completion of this course

CLO1: The students will be abreast with physiological and biochemical basis of crop regulation in flower crops.

CLO2: The students will be able to carry out programmed production of flower crops.

CLO3: Instil the entrepreneurial acumen in the students

THEORY

Unit I

Basis of flowering: Eco-physiological influences on growth and development of flower crops for flowering, Crop load and assimilate partitioning and distribution. Root and canopy regulation.

Unit II

Growth regulators: Study of plant growth regulators including biostimulants and polyamines in floriculture- 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, Plant architecture management for flower crops and ornamental plants, molecular approaches in crop growth regulation.

Unit III

Growth regulation: Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, flower bud initiation, regulation of flowering, photo and thermo periodism, off season production, bulb forcing techniques.

Unit IV

Programmed production: Programmed production of important flower crops like chrysanthemum, tulips, lilium, daffodils, poinsettia, kalanchoe, gypsophila.

PRACTICAL

- Plant architecture studies in important flower crops;
- Bioassay and isolation through chromatographic analysis for auxins, gibberellins, cytokinins, ABA;
- Growth regulation during propagation, dormancy, flowering;
- Photoperiod regulation in short day and long day crops;
- Off season production in important crops;
- Bulb forcing in bulbous ornamental crops;
- Exposure visits.

SUGGESTED TEACHING LEARNING STRATEGIES

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as the per nature of CLO

SUGGESTED READINGS

- Buchanan B, Gruiessam W and Jones R. 2002. Biochemistry and Molecular Biology of Plants. 2015. Wiley Blackwell Publ. 2nd Edition, pp. 1280.
- De Hertagh A and Le Nard M. 1993. The Physiology of Flower Bulbs. Elsevier, London, UK.
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- Roberts J, Downs S and Parker P. 2002. Plant Growth Development: In Plant. Oxford University Press. pp. 221-274.
- Salisbury FB. and Ross CW. 1992. Plant Physiology, Hormones and Plant Regulators: Auxins and Gibberellins. Wadsworth Publ., Belmont. 4th Edition, pp. 357-381.

HOR-C-622 POSTHARVEST BIOLOGY OF FLORICULTURAL CROPS

Semester: First semester **Total Marks: 100**

L+T+P: 2+0+1= 3 Credits **Lecture: 30 Hrs + Tutorial: 0 Hrs+ Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

After successful completion of this course

CLO1: The students will be abreast with physiological and biochemical basis of senescence in flower crops.

CLO2: The students would acquire the required skill sets of managing the storage and packaging methods to be followed in case of flowers.

CLO3: Prepare the students to explore the entrepreneurial options in post harvest management.

THEORY

Unit I

Pre harvest physiology: Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and other biochemical changes, respiration, transpiration in important flower crops. Senescence: Physiology and biochemistry of flowering, enzymatic changes, Ethylene sensitivity, ethylene evolution and management, factors leading to post-harvest loss, pre-cooling.

Unit II

Pigments and secondary metabolites: Biosynthetic pathways of chlorophyll, xanthophyll, carotenoids, flavonoids and anthocyanins and betalains. Chemistry and importance of secondary metabolites. Biochemistry and utilization for commercial products in important flower crops.

Unit III

Storage of flowers: Treatments prior to shipment, viz., precooling, pulsing, impregnation, chemicals, Irradiation, biocontrol agents and natural plant products. Methods of storage: ventilated, refrigerated, Modified atmosphere, Controlled atmosphere storage, cool chain management, physical injuries and disorders in important flower crops. Packaging: Packing methods and transport, Smart technologies in packaging and storage, flower labels value chain in floriculture.

Unit IV

Recent trends: Recent trends- extraction of bio-colours from flowers conventional as well as in-vitro methods and their value addition uses in food and textile industries. Molecular techniques for enhancing postharvest flower quality, transgenics in ornamental plants for enhanced postharvest life.

PRACTICAL

- Improved packaging and storage of important flowers;
- Physiological loss in weight of flowers, estimation of transpiration, respiration rate, ethylene release and study of vase life;
- Extension in cut flower vase life using chemicals;
- Estimation of quality characteristics in stored flowers;
- Estimation of biochemical changes like enzymatic changes, lipids and electrolyte leakage;
- Extraction of flower pigments – Chlorophyll, xanthophylls, carotenoids and anthocyanins;
- Cold chain management – visit to cold storage, MA and CA storage units;
- Project preparation.

SUGGESTED TEACHING LEARNING STRATEGIES

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READINGS

- Buchanan B, Gruiessam W and Jones R. 2002. Biochemistry and Molecular Biology of Plants. 2015. Wiley Blackwell Publ. 2nd edition, pp. 1280.
- Dey PM and Harborne JB. 1997. Plant Biochemistry. Academic Press. 2nd Edition.
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HOR-C-623 BIOTECHNOLOGICAL APPROACHES IN FLORICULTURAL CROPS

Semester: Second semester **Total Marks: 100**

L+T+P: 2+0+1 = 3 **Lecture: 30 Hrs + Tutorial: 0 Hrs+ Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

After successful completion of this course:

CLO1: The students will gain knowledge on scope of biotechnology, micropropagation and in vitro conservation of flower crops.

CLO2: The students will have in depth knowledge about genetic engineering and molecular techniques used in flower crops.

THEORY

Unit I

Scope of biotechnology: Present status of biotechnology, tools techniques and role in floriculture industry, physical factors and chemical factors influencing the growth and development of plant cell, tissue and organs, cyto-differentiation, organogenesis, somatic embryogenesis in important flower crops.

Unit II

Micropropagation: *In-vitro* lines for biotic and abiotic stress – Meristem culture for disease elimination, production of haploids through anther and pollen culture – embryo and ovule culture, micrografting, wide hybridization and embryo rescue techniques, construction of somatic hybrids and cybrids, regeneration and characterization of hybrids and cybrids, in-vitro pollination and fertilization, hardening media, techniques and establishment of tissue culture plants in the primary and secondary nursery in important flower crops. Somaclonal variation and in-vitro conservation: Somoclonal variation and its applications – variability induction through in-vitro mutation, development of cell suspension cultures, types, and techniques, Synthetic Seed technology, in-vitro production of secondary metabolites.

Unit III

Genetic engineering: Gene cloning, genetic engineering: vectors and methods of transformation – electroporation, particle bombardment, Functional gene analysis techniques like PTGS including VIGS in ornamental plants, Agrobacterium mediated, transgenic plants in flower crops, Biosafety of transgenics isolation of DNA, RNA, quantification, Polymerase Chain Reaction for amplification; AGE and PAGE techniques; identification of molecular markers in important flower crops.

Unit IV

Molecular approaches: Molecular markers as a tool for analysis of genetic relatedness and selection in ornamental crops. Molecular control of flower development, light sensing with respect to plant development, flower pigmentation, fragrance, senescence, ethylene synthesis pathway in important flower crops. Molecular biology- Gene isolation, characterization, manipulation and transfer in important flower crops. Construction of c- DNA library, DNA fingerprinting technique in economic flower crop varieties, RNAi, Genome editing basics, molecular approaches to control ethylene response, Fragrance, Plant Architecture, desirable flower traits, colour, shape, improving postharvest life, improving resistance for environmental stress, approaches to improve flower development, pigment production, secondary metabolite production, post harvest biotechnology of flowers, ornamental plants, achievements of bio-technology in flower crops.

PRACTICAL

- Micropropagation, Pollen- Ovule and Embryo culture- Synthetic seed production;
- *In-vitro* mutation induction, *in-vitro* rooting – hardening at primary and secondary nurseries;
- DNA isolation from economic flower crop varieties – Quantification and amplification
- DNA and Protein profiling – molecular markers, PCR Handling;
- Vectors for cloning and particle bombardment;
- DNA fingerprinting of flower crop varieties;
- Project preparation for establishment of low, medium and high cost tissue culture laboratories.

SUGGESTED TEACHING LEARNING STRATEGIES

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars

- Hands on training of different techniques
- Exposure visits

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READINGS

- Chopra VL and Nasim A. 1990. Genetic Engineering and Biotechnology-Concepts, Methods and Applications. Oxford & IBH Publ. Company, USA. pp. 200.
- Debnath M. 2011. Tools and Techniques of Biotechnology. Pointer Publ.
- Glover MD. 1984. Gene Cloning: The Mechanics of DNA Manipulation. Chapman & Hall Publ.
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HOR-C-624 ADVANCES IN LANDSCAPE GARDENING

Semester: Second semester **Total Marks: 100**

L+T+P: 2+0+1 = 3 **Lecture: 30 Hrs + Tutorial: 0 Hrs+ Practical: 30 Hrs**

COURSE LEARNING OUTCOMES

After successful completion of this course:

CLO1: The students will be abreast with the recent advances in landscape gardening

CLO2: Acquire the skills to independently handle landscape projects

THEORY

Unit I

Landscape design: Commercial landscape gardening- History, Plant identification and ecology, Materials of garden design, Design making by different garden styles and types. Design principles in ancient and modern landscape. Principles of designing a commercial landscape project. Role of landscaping in environment improvement, ecology conservation (birds, butterflies, animals). Plant wealth for edges, hedges, herbaceous borders, trees, floral beds, water plants, cacti, ferns, palms, etc

Unit II

Site analysis: Assessing site and plants adaptability for different locations, Landscape engineering (Topographical survey and designing concept including GIS,GPS, Remote sensing), special techniques in garden landscaping (Burlapping, waterscaping, xeriscaping, hardscaping, lawn establishment, topiary styles specializing, bioaesthetic planning).

Unit III

Software in landscaping: Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD and ARCHICAD), GIS as a tool for spatial designing.

Unit IV

Landscaping for different situations: Contemporary landscaping, Urban landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Inventory management, Landscape restoration, Assessing a successful design on site.

PRACTICAL

- Plant identification;
- Materials of garden design, Design making by different garden styles and types;
- Assessing site and plants adaptability for different locations;
- Way of designing a commercial landscape project;
- Landscape engineering (Topographical survey and designing concept);
- Preparation and drawing of site plan;
- Learning the basics in computer aided design (CAD) for developing a garden landscape plan;
- Handling soft landscape materials (AUTOCAD and ARCHICAD), GIS as a tool for spatial designing;
- Case study with the successful landscapist;
- Budget/ Project cost estimating;
- Exposure visits.

SUGGESTED TEACHING LEARNING STRATEGIES

- Lectures
- Group discussions
- Flip classes
- Assignment and group seminars
- Hands on training of different techniques
- Exposure visits

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READINGS

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- Nambisan KMP.1992. Design Elements of Landscape Gardening. Oxford & IBH Publ. Co., New Delhi, India.

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PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

SEMESTER-I

Code	Course Title	Type of Course	Credits
HOR-SU-600	Research Methodology	Supporting	3+1+0
HOR-SU-690	Research & Publication Ethics	Supporting	2+0+0
HOR-C-631	Advances in Production of Plantation and Spice Crops	Major	2+0+1
HOR-C-632	Advances in Production of Medicinal and Aromatic Crops	Major	2+0+1
	HOR-C-601/611/621	Minor	2+0+1
	HOR-C-602/612/622	Minor	2+0+1
	Total		18

SEMESTER-II

Code	Course Title	Type of Course	Credits
HOR-C-691	Research Proposal and Doctoral Seminar	Major	0+0+4
HOR-C-633	Biotechnological Approaches in PSMA Crops	Major	2+0+1
HOR-C-634	Abiotic Stress Management in PSMA Crops	Major	2+0+1
	Total		10

HOR-C-631 ADVANCES IN PRODUCTION OF PLANTATION AND SPICE CROPS

Semester: First semester **Total Marks: 100**

L+T+P; 2+1+0=3 **Credit lecture: 30 hrs + Tutorial: 0 + Practical: 30 Hrs**

COURSE LEARNING OUTCOME

After successful completion of this course, the students are expected to:

CLO1: Be equipped with the latest research outcome in commercial cultivation of plantation and spice crops

CLO1: Be able to start hi-tech plantation and spice crop based enterprises

THEORY

Unit I

Area, production, productivity: Indian and world scenario: Role of plantation and spice crops in national economy, area-production statistics at national and international level, productivity challenges, industrial requirement of plantation and spice crops, demand-supply scenario of plantation and spice crop.

Unit II

Export potential: Export scenario, market opportunities and challenges in plantation and spice crops, global imports and exports, export of organic produce and products. Promotional programmes: Role of commodity boards and directorates in the development programmes of plantation and spice crops, contract farming, Farmer Producer Organizations (FPO) and Farmer Producer Companies (FPC). Varietal wealth and planting material production: Cultivars and improved varieties in plantation and spice crops, mass multiplication techniques, hi-tech nursery techniques.

Unit III

Agro-techniques: Precision farming techniques, HDP systems, fertigation, chemical regulation of crop productivity, protected cultivation of high value crops, mechanization in plantation and spice crops, hydroponics, aeroponics, application of nanotechnology, robotics. Impact of climate change: Impact of biotic and abiotic factors on growth and productivity, climate resilient technologies in plantation and spice crops, soil health management, organic production systems.

Unit IV

Maturity indices and harvest: Influence of pre and post harvest factors on quality of plantation and spice crops, pre and post harvest management techniques for improving quality, good manufacturing practices in plantation and spice sector. Quality standards: Domestic and international standards,

HACCP, BIS standards, domestic and export grades, modern packaging techniques, and export protocols.

Crops

Coconut, Arecanut, Oil palm, Cashew, Coffee, Tea, Cocoa, Rubber, Palmyrah, Black pepper, Cardamom, Ginger, Turmeric, Nutmeg, Cinnamon, Clove, Vanilla, Garcinia, Coriander, Cumin, Fennel, Fenugreek, Ajwain, Dill, Safron

PRACTICAL

- Description of botanical and varietal features-selection of mother palms and elite clones,
- Clonal fidelity testing,
- nursery techniques and propagation methods,
- High density planting, training and pruning practices,
- Fertigation and foliar nutrition,
- Maturity standards,
- Harvesting, curing, processing and grading,
- Project preparation,
- Visit to plantation gardens, commodity boards and plantation and spice based industries.

SUGGESTED TEACHING LEARNING STRATEGIES

• Lecture

• Assignment (Reading/ Writing)

• Presentation of review papers and research articles

• Exposure visits to research centres, industries

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READING

- Afoakwa EO. 2016. Cocoa Production and Processing Technology. CRC Press
- Agarwal S, Divkarasastry EV and Sharma RK. 2001. Seed Spices, Production, Quality and Export. Pointer Publ.
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HOR-C-632 ADVANCES IN PRODUCTION OF MEDICINAL AND AROMATIC CROPS

Semester: First semester **Total Marks: 100**

L+T+P: 2+0+1=3 **Credit lecture: 30 hrs+ Tutorial: 0 + Practical: 30 Hrs**

COURSE LEARNING OUTCOME

After successful completion of this course, the students are expected to:

CLO1: Be equipped with the latest research out come in commercial cultivation of medicinal and aromatic crops

CLO2: Be able to start hi-tech medicinal and aromatic crop based enterprises

THEORY

Unit I

Biodiversity of medicinal and aromatic crops (MAPs): Biodiversity of MAPs, conservation networks, global initiatives on medicinal plants conservation and development, World history on usage of MAPs, preference to natural products. Indian traditional wisdom and heritage, Indian herbal wealth, documentations, databases, scientific validation. Area, production and productivity statistics: Role of medicinal and aromatic crops in national economy, area-production statistics at national and international level, productivity challenges, Trends in food, flavouring, perfumery and cosmetic industries, requirement in the ayurvedic, pharmaceutical, perfume and cosmetic industries, demand-supply scenario of MAPs. Export potential: Export and import of crude drugs, standardized extracts, aromatic plants, essential oils. Intellectual Property Rights, patents. Contract farming. Role of Medicinal Plant Board in promotional programmes of MAPs.

Unit II

Domestication of medicinal and aromatic crops: Need for domestication, changes on domestication, influence of environment on secondary metabolite production, developing cultivation packages for emerging crops. Varietal wealth and planting material production: Cultivars and improved varieties in medicinal and aromatic crops, mass multiplication techniques, micropropagation, hi-tech nursery techniques.

Unit III

Agro-techniques: Advanced research in the field of growth and development, nutrition and irrigation requirements, inter culture, mulching, weed control. Precision farming techniques, HDP systems, fertigation, chemical regulation of crop productivity, protected cultivation of high-value crops, hydroponics, aeroponics, application of nanotechnology, nano-fertilizers, nano-pesticides, robotics. Maturity indices and harvest: Influence of pre and post harvest factors on quality of medicinal and aromatic crops, pre and post-harvest management techniques for improving quality, good manufacturing practices in herbal sector.

Unit IV

Modern methods of extraction of MAPs: Advanced essential oil extraction and value addition methods in aromatic plants, advances in phytochemical extraction technologies, separation of bio-molecules, phytochemicals and drug development. Pharmacology and pharmacognosy, *in vivo* and *in-vitro* extraction of secondary metabolites, bioreactors.

Quality standards: Quality standards in medicinal and aromatic plants, quality standards in crude drugs and finished products, use of aroma chemicals, aroma therapy, advanced research in biomedicines, nutraceuticals and natural drugs, American, European and Asian legislations on plant drugs, domestic and international standards, modern packaging techniques.

Crops

A. Medicinal crops: Coleus, Glory lily, Senna, Periwinkle, Stevia, Aswagandha, Sarpagandha, Aloe, *Phyllanthus amarus*, *Andrographis paniculata*, Isabgol, Poppy, *Digitalis* sp., *Commiphora* sp., Ipecac, Henbane, *Ocimum* sp., Centella, Bacopa, Saraca, Valerian, Jatamansi, Aconits, Ephedra and Bael.

B. Aromatic crops: Palmarosa, Lemongrass, Citronella, Vetiver, Geranium, Artemisia, Mint, Eucalyptus, Rosemary, Thyme, Patchouli, Rose, Jasmine, Lavender.

PRACTICAL

- Description of botanical and varietal features-selection of mother palms and elite clones,
- Clonal fidelity testing,
- nursery techniques and propagation methods,
- High density planting, training and pruning practices,
- Fertigation and foliar nutrition,
- Maturity standards,
- Harvesting, curing, processing and grading,
- Extraction techniques
- project preparation,

SUGGESTED TEACHING LEARNING STRATEGIES

• Lecture

• Assignment (Reading/ Writing)

• Presentation of review papers and research articles

• Exposure visits to research centres, industries

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READING

- Dharamvir H. 2007. Bioactive Medicinal Plants. Gene Tech Books.
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- Farooqi AA, Khan MM and Vasundhara M. 2001. Production Technology of Medicinal and Aromatic Crops. Natural Remedies Pvt. Ltd.
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HOR-C-633 BIOTECHNOLOGICAL APPROACHES IN PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS

Semester: Second semester **Total Marks: 100**

L+T+P: 2+0+1=3 **Credit lecture: 30 hrs+ Tutorial: 0 + Practical: 30 Hrs**

COURSE LEARNING OUTCOME

The learner is expected to be:

CLO1: Acquainted with the applications of biotechnology in PSMA crops

CLO2: Able to start modern labs based on biotechnology in PSMA crops

THEORY

Unit I

In-vitro mass multiplication techniques: *In-vitro* conservation of medicinal and aromatic crops, direct and indirect organogenesis, micro grafting, hardening techniques, production of microrhizomes.

Unit II

In-vitro breeding: Production of haploids, somaclones and identification of somaclonal variants, *in-vitro* techniques to overcome fertilization barriers, Protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in-vitro* mutation for biotic and abiotic stresses, disease elimination in crops.

Unit III

Transgenic crops: Recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology. Role of molecular markers in characterization of transgenic crops, finger printing of cultivars, etc., achievements, problems and future thrusts.

Unit IV

In-vitro production of secondary metabolites: *In-vitro* production and characterization of secondary metabolites, bioreactors.

Crops

Coconut, Rubber, Oil palm, Coffee, Tea, Cocoa, Black pepper, Cardamom, Turmeric, Ginger, Vanilla, Periwinkle, Rauvolfia, Mint, Cymbopogon grasses, Medicinal coleus, *Ocimum* sp., Aswagandha, Aloe, Safed musli, Stevia

PRACTICAL

- Micropropagation, Pollen- Ovule and Embryo culture- Synthetic seed production;
- *In-vitro* mutation induction, *in-vitro* rooting – hardening at primary and secondary nurseries;
- DNA isolation from economic flower crop varieties – Quantification and amplification
- DNA and Protein profiling – molecular markers, PCR Handling;
- Vectors for cloning and particle bombardment;
- DNA fingerprinting of flower crop varieties;
- Project preparation for establishment of low, medium and high cost tissue culture laboratories.

SUGGESTED TEACHING LEARNING STRATEGIES

- Lecture-cum discussion, library readings, critical discussion.
- Organizing group discussions, case studies, and projects.
- Individual presentation by student on selected topic.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READING

- Afoakwa EO. 2016. Cocoa Production and Processing Technology. CRC Press. Bajaj YPS. Ed. 1987. Biotechnology in Agriculture and Forestry. Springer.
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HOR-C-634 ABIOTIC STRESS MANGEMENT IN PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

Semester: Second semester **Total Mark: 100**

L+T+P; 2+0+1=3 **Credit lecture: 30 hrs + Tutorial: 0 + Practical: 30 Hrs**

COURSE LEARNING OUTCOME

The learner is expected to get empowered on

CLO1: The impact of abiotic stress on PSMA crop production

CLO2: The mitigation measures to be adopted for sustaining PSMA crop production

THEORY

Unit I

Temperature and water stress: Stresses due to water (high and low), temperature (high and low), symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality.

Unit II

Definition, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.), salt stress Stress due to soil conditions and salts: Alkainity, salinity, iron toxicity, fertilizer toxicity symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality.

Unit III

Pollution stress: Gaseous pollutants and heavy metals, symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality.

Unit IV

Other stresses: Stress due to radiation, wind, nutrients. symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality. Climate resilient technologies: Plantation crops, Spice crops, Medicinal and aromatic crops. Waste management: Alternate farming systems, Zero waste management, Microbial waste management.

PRACTICAL

• Analysis of plant stress factors;

- Relative water content;
- Chlorophyll stability index;
- Plant waxes;
- Stomatal diffusive resistance;
- Transpiration;
- Photosynthetic rates;
- Calculation of water use efficiency and growth rates;
- Identifying abiotic stress symptoms and injuries;
- Use of anti-transpirants;
- Managing nutrient stress;
- Stress management by hormones;
- Screening for abiotic stress tolerance;
- Weather data analyses and quantification of climate change;
- Cropping pattern changes due to climate extremities;
- Phenological and quality changes in PSMAs;
- Pesticide residue analysis in PSMAs.

SUGGESTED TEACHING LEARNING STRATEGIES

- Lecture-cum discussion, library readings, critical discussion.
- Organizing group discussions, case studies, and projects.
- Individual presentation by student on selected topic.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks:	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks:	Semester examinations conducted by the university will be considered as the mode of summative assessment.		

Note: Concern teachers can choose any mode of formative assessment as per the nature of CLO

SUGGESTED READING

- Afoakwa EO. 2016. Cocoa Production and Processing Technology. CRC Press.
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