RADHA GOVIND UNIVERSITY

RAMGARH, JHARKHAND

DEPARTMENT OF AGRICULTURAL SCIENCES

CHOICE BASED CREDIT SYSTEM CURRICULUM SYLLABUS
FOR MASTER OF SCIENCE IN HORTICULTURE PROGRAMME
SUBJECT CODE = 22

FOR MASTER COURSE IN HORTICULTURE UNDER
RADHA GOVIND UNIVERSITY

Implemented w.e.f.
Academic Session 2026-27 & onwards

Academic Regulations for PG Programme as per ICAR

1. Academic Year and Registration

1.1 An academic year shall be normally from July to June of the following calendar year otherwise required under special situations. It shall be divided into two academic terms known as semesters. Dates of registration, commencement of instructions, semester end examination, end of semester and academic year, etc. The Academic Calendar shall be developed by the concerned University from time to time and notified accordingly by the Registrar in advance.

2. Credit requirements

2.1 Framework of the courses

The following nomenclature and Credit Hrs need to be followed while providing the syllabus for all the disciplines:

	Masters' Programme
(i) Course work	
Major courses	20
Minor courses	08
Supporting courses	06
Common courses	05
Seminar	01
(ii) Thesis Research	30
Total	70

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.

Common Courses: The following courses (one credit each) will be offered to all students undergoing Master's degree programme:

1. Library and Information Services
2. Technical Writing and Communications Skills
3. Intellectual Property and its management in Agriculture
4. Basic Concepts in Laboratory Techniques
5. Agricultural Research, Research Ethics and Rural Development Programmes

Some of these courses are already in the form of e-courses/ MOOCs. The students may be allowed to register these courses/ similar courses on these aspects, if available online on SWAYAM or any other platform. If a student has already completed any of these courses during UG, he/ she may be permitted to register for other related courses with the prior approval of the Head of Department (HoD)/ Board of Studies (BoS).

2.2 Supporting Courses

The following courses are being offered by various disciplines (The list is only indicative). Based on the requirement, any of the following courses may be opted under the supporting courses. The syllabi of these courses are available in the respective disciplines. If required, the contents may be modified to suit the individual discipline with approval of the concerned BoS:

Course Code	Course Title	Credit Hours
STAT 501	Mathematics for Applied Sciences	2+0
STAT 502	Statistical Methods for Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 512	Basic Sampling Techniques	2+1
STAT 521	Applied Regression Analysis	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
MCA 501	Computers Fundamentals and Programming	2+1
MCA 502	Computer Organization and Architecture	2+0
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 501	Basic Biochemistry	3+1
BIOCHEM 505	Techniques in Biochemistry	2+2

2.3 Syllabus of Common Courses for PG programmes

LIBRARY AND INFORMATION SERVICES (0+1)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines, etc.) of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e- resources access methods.

TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

To equip the students/ scholars with skills to write dissertations, research papers, etc. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods,

experimental results and discussion);

- Writing of abstracts, summaries, précis, citations, etc.;
- Commonly used abbreviations in the theses and research communications;
- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading;
- Writing of a review article;
- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- Accentual pattern: Weak forms in connected speech;
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

Suggested Readings

1. Barnes and Noble. Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language*.
2. *Chicago Manual of Style*. 14th Ed. 1996. Prentice Hall of India.
3. *Collins' Cobuild English Dictionary*. 1995.
4. Harper Collins. Gordon HM and Walter JA. 1970. *Technical Writing*. 3rd Ed.
5. Holt, Rinehart and Winston. Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English*. 6th Ed. Oxford University Press.
6. James HS. 1994. *Handbook for Technical Writing*. NTC Business Books.
7. Joseph G. 2000. *MLA Handbook for Writers of Research Papers*. 5th Ed. Affiliated East-West Press.
8. Mohan K. 2005. *Speaking English Effectively*. MacMillan India.

9. Richard WS. 1969. *Technical Writing*.
10. Sethi J and Dhamija PV. 2004. *Course in Phonetics and Spoken English*. 2nd Ed. Prentice Hall of India.
11. Wren PC and Martin H. 2006. *High School English Grammar and Composition*.
S. Chand & Co.

INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of Intellectual Property Rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge- based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National

Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

1. Erbisch FH and Maredia K.1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
2. Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
3. *Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC and Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol.
   V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
6. Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;

- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralisation of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;
- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings

1. Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.

2. Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development

Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary

Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

1. Bhalla GS and Singh G. 2001. *Indian Agriculture - Four Decades of Development*. Sage Publ.
2. Punia MS. *Manual on International Research and Research Ethics.* CCS Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. *Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives*. Mittal Publ.
4. Singh K. 1998. *Rural Development - Principles, Policies and Management*. Sage Publ.

2.4 Mandatory requirement of seminars

- It has been agreed to have mandatory seminars one in Masters (One Credit) and two in Doctoral programmes (two Credits).
- The students should be encouraged to make presentations on the latestdevelopments and literature in the area of research topic. This will provide training to the students on preparation for seminar, organizing the work, critical analysis of data and presentation skills.

3. Residential requirements

- The minimum and maximum duration of residential requirement for Masters'

P.G. Degree Programmes	Duration of Residential Requirement	
	Minimum	Maximum
Masters' Degree	2 Academic Years (4 Semesters)	5 Academic Years (10 Semesters)

*Student may be allowed to discontinue temporarily only after completion of course work

In case a student fails to complete the degree programme within the maximum duration of residential requirement, his/ her admission shall stand cancelled. The requirement shall be treated as satisfactory in the cases in which a student submits his/ her thesis any time during the 4th of his/ her residentship at the University for Masters' programme, respectively.

4. Evaluation of course work and comprehensive examination
   - For M.Sc., multiple levels of evaluation (First Test, Midterm and Final semester) is desirable. However, it has been felt that the comprehensive examination is redundant for M.Sc. students.
5. Advisory System

5.1 Advisory Committee

- There shall be an Advisory Committee for every student consisting of not fewer than three members in the case of a candidate for Masters' degree with the Advisor as Chairperson. The Advisory Committee should have representatives from the major and minor fields amongst the members of the Post-

graduate faculty accredited for appropriate P.G. level research. However, in those departments where qualified staff exists but due to unavoidable reasons Post-graduate degree programmes are not existing, the staff having Post-graduate teaching experience of two years or more may be included in the Advisory Committee as member representing the minor.

- At any given time, a P.G. teacher shall not be a Chairperson, Advisory Committee (for Master's programmes) for more than five students.

❖ Compliance with the National Education Policy-2020

- While implementing the course structure and contents recommended by the BSMA Committees, the Higher Education Institutions (HEIs) are required to comply with the provisions of National Education Policy-2020, especially the following aspects:
- Given the 21st century requirements, quality higher education must aim to develop good, thoughtful, well-rounded, and creative individuals. It must enable an individual to study one or more specialized areas of interest at a deep level, and also develop character, ethical and Constitutional values, intellectual curiosity, scientific temper, creativity, spirit of service, and 21st century capabilities across a range of disciplines including sciences, social sciences, arts, humanities, languages, as well as professional, technical, and vocational subjects. A quality higher education must enable personal accomplishment and enlightenment, constructive public engagement, and productive contribution to the society. It must prepare students for more meaningful and satisfying lives and work roles and enable economic independence (9.1.1. of NEP-2020).
- At the societal level, higher education must enable the development of an enlightened, socially conscious, knowledgeable, and skilled nation that can find and implement robust solutions to its own problems. Higher education must form the basis for knowledge creation and innovation thereby contributing to a growing national economy. The purpose of quality higher education is, therefore, more than the creation of greater opportunities for individual employment. It represents the key to more vibrant, socially engaged, cooperative communities and a happier, cohesive, cultured, productive, innovative, progressive, and prosperous nation (9.1.3. of NEP-2020).
- Flexibility in curriculum and novel and engaging course options will be on offer to students, in addition to rigorous specialization in a subject or subjects. This will be encouraged by increased faculty and institutional autonomy in setting curricula. Pedagogy will have an increased emphasis on communication, discussion, debate, research, and opportunities for cross-disciplinary and interdisciplinary thinking (11.6 of NEP-2020).
- As part of a holistic education, students at all HEIs will be provided with opportunities for

internships with local industry, businesses, artists, crafts persons, etc., as well as research internships with faculty and researchers at their own or other HEIs/ research institutions, so that students may actively engage with the practical side of their learning and, as a by-product, further improve their employability (11.8 of NEP-2020).

- HEIs will focus on research and innovation by setting up start-up incubation centres; technology development centres; centres in frontier areas of research; greater industry-academic linkages; and interdisciplinary research including humanities and social sciences research (11.12. of NEP-2020).
- Effective learning requires a comprehensive approach that involves appropriate curriculum, engaging pedagogy, continuous formative assessment, and adequate student support. The curriculum must be interesting and relevant, and updated regularly to align with the latest knowledge requirements and to meet specified learning outcomes. High-quality pedagogy is then necessary to successfully impart the curricular material to students; pedagogical practices determine the learning experiences that are provided to students, thus directly influencing learning outcomes. The assessment methods must be scientific, designed to continuously improve learning and test the application of knowledge. Last but not least, the development of capacities that promote student wellness such as fitness, good health, psycho-social well-being, and sound ethical grounding are also critical for high-quality learning (12.1. of NEP-2020).

Course title with credit load M.Sc. (Hort.) in Fruit Science

Course Code	Course Title	Credit Hours
	Major Courses (20 Credits)	
FSC 501*	Tropical Fruit Production	2+1
FSC 502*	Sub-Tropical and Temperate Fruit Production	2+1
FSC 503*	Propagation and Nursery Management of Fruit Crops	2+1
FSC 504*	Breeding of Fruit Crops	2+1
FSC 505	Systematics of Fruit Crops	2+1
FSC 506	Canopy Management in Fruit Crops	1+1
FSC 507	Growth and Development of Fruit Crops	2+1
FSC 508	Nutrition of Fruit Crops	2+1
FSC 509	Biotechnology of Fruit Crops	2+1
FSC 510	Organic Fruit Culture	2+1
FSC 511	Export Oriented Fruit Production	2+1
FSC 512	Climate Change and Fruit Crops	1+0
FSC 513	Minor Fruit Production	2+1
	Minor Courses	**08**
	Supporting Courses	**06**
	Common compulsory courses	**05**
FSC 591	Seminar	0+1
FSC 599	Research	0+30
	Total Credits	**70**

*Compulsory among major courses

Course Contents

M.Sc. (Hort.) in Fruit Science

I. Course Title: Tropical Fruit Production

II. Course Code : FSC 501

III. Credit Hours : (2+1)

IV. Why this course ?

Tropical fruits occupy a distinct place in global fruit production. Apart from ecological specificities, tropical fruits enjoy favour among masses being delicious and nutritious. As such, the course has been designed to provide update knowledge on various production technologies of tropical fruits on sustainable basis.

V. Aim of the course

To impart comprehensive knowledge to the students on cultural and management practices for growing tropical fruits.

The course is organised as follows:

No.	Blocks	Units	
1	Introduction	I	Importance and Background
2	Agro-Techniques	I	Propagation, Planting and Orchard Floor Management
3	Crop Management	I	Flowering, Fruit-Set and Harvesting

VI. Theory

Block 1: Introduction

Unit I: Importance and Background: Importance, origin and distribution, major

species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements.

Block 2: Agro-techniques

Unit I: Propagation, Planting and Orchard Floor Management: Asexual and sexual methods of propagation, planting systems and planting densities, training and pruning methods, rejuvenation, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Block 3: Crop Management

Unit I: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders – causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

Mango, Banana, Guava, Pineapple, Papaya, Avocado, Jackfruit, Annonas, Aonla, Ber, etc.

VII. Practicals

- Distinguished features of tropical fruit species, cultivars and rootstocks (2);
- Demonstration of planting systems, training and pruning (3);
- Hands on practices on pollination and crop regulation (2);
- Leaf sampling and nutrient analysis (3);
- Physiological disorders-malady diagnosis (1);
- Physico-chemical analysis of fruit quality attributes (3);
- Field/ Exposure visits to tropical orchards (1);
- Project preparation for establishing commercial orchards (1).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

The students are expected to equip themselves with know-how on agro-techniques for establishment and management of an orchard leading to optimum and quality fruit production of tropical fruits.

X. Suggested Reading

Bartholomew DP, Paull RE and Rohrbach KG. 2002. *The Pineapple: Botany, Production, and Uses.* CAB International.

Bose TK, Mitra SK and Sanyal D. 2002. *Fruits of India – Tropical and Sub-Tropical*.3rd Edn. Naya Udyog, Kolkata.

Dhillon WS. 2013. *Fruit Production in India.* Narendra Publ. House, New Delhi.

Iyer CPA and Kurian RM. 2006. *High Density Planting in Tropical Fruits: Principlesand Practices.* IBDC Publishers, New Delhi.

Litz RE. 2009. *The Mango: Botany, Production and Uses*. CAB International.

Madhawa Rao VN. 2013. *Banana.* ICAR, New Delhi.

Midmore D. 2015. *Principles of Tropical Horticulture*. CAB International. Mitra SK and Sanyal D. 2013. *Guava,* ICAR, New Delhi.

Morton JF. 2013. *Fruits of Warm Climates.* Echo Point Book Media, USA.

Nakasome HY and Paull RE. 1998. *Tropical Fruits*. CAB International. Paull RE and Duarte O. 2011. *Tropical Fruits* (Vol. 1). CAB International.

Rani S, Sharma A and Wali VK. 2018. *Guava* (*Psidium guajava* L.). Astral, New Delhi. Robinson JC and Saúco VG. 2010. *Bananas and Plantains*. CAB International.

Sandhu S and Gill BS. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi. Schaffer B, Wolstenholme BN and Whiley AW. 2013. *The Avocado: Botany, Production and Uses.* CAB International.

Sharma KK and Singh NP. 2011. *Soil and Orchard Management*. Daya Publishing House, New Delhi.

Valavi SG, Peter KV and Thottappilly G. 2011. *The Jackfruit*. Stadium Press, USA.

I. **Course Title : Subtropical and Temperate Fruit Production**

II. **Course Code : FSC 502**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

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

V. Aim of the course

To impart comprehensive knowledge to the students on cultural and management practices for growing subtropical and temperate fruits.

The course is organised as follows:

No.	Blocks	Units
1	Introduction	Importance and Background
2	Agro-Techniques	Propagation, Planting and Orchard Floor Management
3	Crop Management	Flowering, Fruit-Set and Harvesting

VI. Theory

Block 1: Introduction

Unit I: Importance and Background: Origin, distribution and importance, major species, rootstocks and commercial varieties of regional, national and

international importance, eco-physiological requirements.

Block 2: Agro-Techniques

Unit I: Propagation, Planting and Orchard Floor Management: Propagation, planting systems and densities, training and pruning, rejuvenation and replanting, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.

Block 3: Crop Management

Unit I: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders- causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.

Crops

Citrus, Grapes, Litchi, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherries, Berries, Persimmon, Kiwifruit, Nuts- Walnut, Almond, Pecan, etc.

VII. Practicals

- Distinguished features of fruit species, cultivars and rootstocks (2);
- Demonstration of planting systems, training and pruning (3);
- Hands on practices on pollination and crop regulation (2);

- Physiological disorders-malady diagnosis (1);
- Physico-chemical analysis of fruit quality attributes (3);
- Field/ Exposure visits to subtropical and temperate orchards (1);
- Project preparation for establishing commercial orchards (1).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

After successful completion of the course, the student are expected to equip themselves with principles and practices of producing subtropical (citrus, grapes, litchi, pomegranate, etc.) and temperate fruits (apple, pear, peach, plum, apricot, cherries, berries, kiwifruit, etc.) and nuts (almond, walnut, pecan, etc.)

X. Suggested Reading

Chadha KL and Awasthi RP. 2005. *The Apple*. Malhotra Publishing House, New Delhi. Chadha TR. 2011. *A Text Book of Temperate Fruits*. ICAR, New Delhi

Childers NF, Morris JR and Sibbett GS. 1995. *Modern Fruit Science: Orchard and Small Fruit Culture*. Horticultural Publications, USA.

Creasy G and Creasy L. 2018. *Grapes.* CAB International. Davies FS and Albrigo LG. 1994. *Citrus.* CAB International.

Dhillon WS. 2013. *Fruit Production in India.* Narendra Publishing House, New Delhi. Jackson D, Thiele G, Looney NE and Morley-Bunker M. 2011.

Temperate and Subtropical Fruit Production. CAB International.

Ladanyia M. 2010. *Citrus Fruit: Biology, Technology and Evaluation*. Academic Press. Layne DR and Bassi D. 2008. *The Peach: Botany, Production and Uses*. CABI.

Menzel CM and Waite GK. 2005. *Litchi and Longan: Botany, Production and Uses*. CAB International.

Pandey RM and Randey SN. 1996. *The Grape in India*. ICAR, New Delhi.

Rajput CBS, and Haribabu RS. 2006. *Citriculture,* Kalyani Publishers, New Delhi. Sandhu S and Gill BS. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi.

Sharma RM, Pandey SN and Pandey V. 2015. *The Pear – Production, Post-harvest Management and Protection*. IBDC Publisher, New Delhi.

Sharma RR and Krishna H. 2018. *Textbook of Temperate Fruits.* CBS Publishers and Distributors Pvt. Ltd., New Delhi.

Singh S, Shivshankar VJ, Srivastava AK and Singh IP. 2004. *Advances in Citriculture.* NIPA, New Delhi.

Tromp J, Webster AS and Wertheim SJ. 2005. *Fundamentals of Temperate Zone Tree Fruit Production.*Backhuys Publishers, Lieden, The Netherlands.

Webster A and Looney N. *Cherries: Crop Physiology, Production and Uses.* CABI.

Westwood MN. 2009. *Temperate Zone Pomology:Physiology and Culture.* Timber Press, USA.

I. Course Title : Propagation and Nursery Management in Fruit Crops

II. Course Code : FSC 503

III. Credit Hours : (2+1)

IV. Why this course ?

Availability of sufficient and healthy planting material is pivotal for

expanding fruit culture. This necessitates requisite skill and efficient multiplication protocols for raising plants and their in house management prior to distribution or field transfer, hence the course is developed.

V. Aim of the course

To understand the principles and methods of propagation and nursery management in fruit crops.

The course is organised as follows:

No.	Blocks	Units
1	Introduction	I General Concepts and Phenomena
2	Propagation	I Conventional Asexual Propagation II Micropropagation
3	Nursery Regulation	I Management Practices and

VI. Theory

Block 1: Introduction

Unit 1: General Concepts and Phenomena: Introduction, understanding cellular basis for propagation, sexual and asexual propagation, apomixis, polyembryony, chimeras. Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seed germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing.

Block 2: Propagation

Unit I: Conventional Asexual Propagation: Cutting– methods, rooting of

soft and hardwood cuttings under mist and hotbeds. Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

Budding and grafting – principles and methods, establishment and management of bud wood bank. Stock, scion and inter stock relationship – graft incompatibility, physiology of rootstock and top working.

Unit II: Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques – *in-vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules.

Block 3: Nursery

Unit I: Management Practices and Regulation: Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, nursery accreditation, import and export of seeds and planting material and quarantine.

VII. Practical

- Hands on practices on rooting of dormant and summer cuttings (3);
- Anatomical studies in rooting of cutting and graft union(1);
- Hands on practices on various methods of budding and grafting (4);
- Propagation by layering and stooling (2);

- Micropropagation- explant preparation, media preparation, culturing – meristem tip culture, axillary bud culture, micro-grafting, hardening (4);
- Visit to commercial tissue culture laboratories and accredited nurseries (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 equip to acquire skills and knowledge on principles and practices of macro and micropropagation and the handling of propagated material in nursery.

X. Suggested Reading

Bose TK, Mitra SK and Sadhu MK. 1991. *Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash, Kolkatta.

Davies FT, Geneve RL and Wilson SB. 2018. *Hartmann and Kester's Plant Propagation- Principles and Practices.* Pearson, USA/ PrenticeHall of India. New Delhi.

Gill SS, Bal JS and Sandhu AS. 2016. *Raising Fruit Nursery*. Kalyani Publishers,New Delhi. Jain S and Ishil K. 2003. *Micropropagation of Woody Trees and Fruits*. Springer.

Jain S and Hoggmann H. 2007. *Protocols for Micropropagation of Woody Trees and Fruits*. Springer.

Joshi P. 2015. *Nursery Management of Fruit Crops in India.* NIPA, New Delhi.

Love *et al.* 2017. *Tropical Fruit Tree Propagation Guide* UH-CTAHR F_N_49.

College of Tropical Agriculture and Human Resources University of Hawaii at Manwa, USA.

Peter KV, eds. 2008. *Basics of Horticulture.* New India Publishing Agency, New Delhi. Rajan S and Baby LM. 2007. *Propagation of Horticultural Crops.* NIPA, New Delhi.

Sharma RR. 2014. *Propagation of Horticultural Crops.* Kalyani Publishers, New Delhi. Sharma RR and Srivastav M. 2004. *Propagation and Nursery Management.* Intl. Book Publishing Co., Lucknow.

Singh SP. 1989. *Mist Propagation*. Metropolitan Book Co.

Singh RS. 2014. *Propagation of Horticultural Plants: Arid and Semi-Arid Regions.* NIPA, New Delhi.

Tyagi S. 2019. *Hi-Tech Horticulture.* Vol I: *Crop Improvement, Nursery and Rootstock Management.* NIPA, New Delhi.

I. Course Title : Breeding of Fruit Crops

II. Course Code : FSC 504

III. Credit Hours : (2+1)

IV. Why this course ?

Development of genetically improved varieties and rootstock is a continuous process which is realized through selection and breeding approaches. This is necessary to enhance the productivity and meet ever-changing climatic conditions and market/ consumer preferences. As such, a course is formulated to generate know-how on genetic and breeding aspects of fruit crops.

V. Aim of the course

To impart comprehensive knowledge on principles and practices of fruit breeding.

No.	Blocks	Units
1.	Introduction	Importance, Taxonomy and Genetic Resources
2.	Reproductive Biology	Blossom Biology and Breeding Systems
3.	Breeding approaches Breeding	Conventional and Non-Conventional

VI. Theory

Block 1: Introduction

Unit I: Importance, Taxonomy and Genetic Resources: Introduction and importance, origin and distribution, taxonomical status – species and cultivars, cytogenetics, genetic resources.

Block 2: Reproductive Biology

Unit I: Blossom Biology and Breeding Systems: Blossom biology, breeding systems – spontaneous mutations, polyploidy, incompatibility, sterility, parthenocarpy, apomixis, breeding objectives, ideotypes.

Block 3: Breeding Approaches

Unit I: Conventional and Non-Conventional Breeding: Approaches for crop improvement – direct introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrusts.

Crops

Mango, Banana, Pineapple, Citrus, Grapes, Litchi, Guava, Pomegranate, Papaya, Apple, Pear, Plum, Peach, Apricot, Cherries, Strawberry, Kiwifruit, Nuts

VII. Practicals

- Exercises on bearing habit, floral biology (2);
- Pollen viability and fertility studies (1);
- Hands on practices in hybridization (3);
- Raising and handling of hybrid progenies (2);
- Induction of mutations and polyploidy (2);
- Evaluation of biometrical traits and quality traits (2);
- Screening for resistance against abiotic stresses (2);
- Developing breeding programme for specific traits (2);
- Visit to research stations working on fruit breeding (1).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Have an understanding on importance and peculiarities of fruit breeding.

- Have an updated knowledge on reproductive biology, genetics and inherent breeding systems.
- Have detailed knowledge of various methods/ approaches of breeding fruit crops

x. Suggested Reading

Abraham Z. 2017. *Fruit Breeding*. Agri-Horti Press, New Delhi.

Badenes ML and Byrne DH. 2012. *Fruit Breeding*. Springer Science, New York. Dinesh MR. 2015. *Fruit Breeding*, New India Publishing Agency, New Delhi.

Ghosh SN, Verma MK and Thakur A. 2018. *Temperate Fruit Crop Breeding-Domestication to Cultivar Development.* NIPA, New Delhi.

Hancock JF. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. Springer Science, New York.

Jain SN and Priyadarshan PM. 2009. *Breeding Plantation and Tree Crops: Tropical Species.*

Springer Science, New York.

Jain S and Priyadarshan PM. 2009. *Breeding Plantation and Tree Crops: Temperate Species*.

Springer Science, New York.

Janick J and Moore JN. 1996. *Fruit Breeding*. Vols. I–III. John Wiley & Sons, USA. Kumar N. 2014. *Breeding of Horticultural Crops:Principles and Practices*. NIPA, N. Delhi. Moore JN and Janick J. 1983. *Methods in Fruit Breeding*. Purdue University Press, USA. Ray PK. 2002. *Breeding Tropical and Subtropical Fruits.* Narosa Publ. House, New Delhi.

I. **Course Title : Systematics of Fruit Crops**

II. **Course Code : FSC 505**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Life forms and their behaviour are best understood if properly described to the stake holders. Therefore, identification and characterization are pre-requisites to distinctly describe the plant species. The fruit crop species are no exception, and thus an exclusive course on their categorisation and description exhibiting a great deal of variation.

V. Aim of the course

To acquaint with the classification, nomenclature and description of various fruit crops.

The course is organised as under:

No.	Blocks	Units
1	Biosystematics	Nomenclature and Classification
2	Botanical Keys and Descriptors	Identification and Description
3	Special Topics	Registration and Modern Systematics

VI. Theory

Block 1: Biosystematics

Unit I: Nomenclature and Classification: Biosystematics – introduction and significance; history of nomenclature of cultivated plants, classification and nomenclature systems; International code of nomenclature for cultivated plants

Unit I: Identification and Description: Methods of identification and description of cultivated fruit and nut species and their wild relatives features; development of plant keys for systematic identification and classification.

Development of fruit crop descriptors- based upon Bioversity International Descriptors and UPOV/ DUS test guidelines, botanical and pomological description of major cultivars and rootstocks of tropical, subtropical and temperate fruits and nut crops

Block 3: Special Topics

Unit I: Registration and Modern Systematics: Registration, Use of chemotaxonomy, biochemical and molecular markers in modern systematics

VII. Practicals

- Exercises on identification and pomological description of various fruit species and cultivars (6);
- Development of descriptive blanks *vis-a-vis* UPOV/ DUS test guidelines and Bioversity International (4);
- Descriptors for developing fruit species and cultivar descriptive databases (4);
- Visits to major germplasm centres and field genebanks (2).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

After successful completion of the course, the students would be able to—

- Categorise different fruit species into broad groups.
- Identify various fruit cultivars on basis of distinguishing features
- Characterize fruit cultivars for description, registration and protection

X. Suggested Reading

ASHS. 1997. *The Brooks and Olmo Register of Fruit and NutVarieties*. 3rd Ed. ASHS Press. Bhattacharya B and Johri BM. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Pub.

House, New Delhi.

Pandey BP. 1999. *Taxonomy of Angiosperms*. S. Chand & Co. New Delhi.

Pareek OP and Sharma S. 2017. *Systematic Pomology*. Scientific Publishers, Jodhpur. Sharma G, Sharma OC and Thakur BS. 2009. *Systematics of Fruit Crops*. NIPA, New Delhi. Simpson M. 2010. *Plant Systematics*. 2nd Edn. Elsevier.

Spencer RR, Cross R and Lumley P. 2003. *Plant Names*. 3rd Ed. *A Guide to Botanical Nomenclature,* CISRO, Australia.

Srivastava U, Mahajan RK, Gangopadyay KK, Singh M and Dhillon BS. 2001. *Minimal Descriptors of Agri-Horticultural Crops. I: Fruits*. NBPGR, New Delhi.

Zielinski QB. 1955. *Modern Systematic Pomology.* Wm. C. Brown Co., Iowa, USA.

I. **Course Title : Canopy Management of Fruit Crops**

II. **Course Code : FSC 506**

III. **Credit Hours : (1+1)**

IV. **Why this course ?**

Plant architecture plays an important role in enhancing photosynthetic efficiency and resultant quantity and quality of the fruit produce. Manipulation of plant growth and development can be done by employing different training and pruning procedures besides through the use of growth regulators, specific rootstocks, etc. Hence this course is developed to address the aforesaid issues.

V. Aim of the course

To impart knowledge on principles and practices in management of canopy architecture for quality fruit production.

The course organisation is as follows:

No.	Blocks	Units
1	Canopy Architecture	Introduction, types and Classification
2	Canopy Management	Physical Manipulation and Growth regulation

VI. Theory

Block 1: Canopy Architecture

Unit I: Introduction, Types and Classification: Canopy management – importance and factors affecting canopy development. Canopy

types and structures, canopy manipulation for optimum utilization of light and its interception. Spacing and utilization of land area – Canopy classification.

Block 2: Canopy Management

Unit I: Physical Manipulation and Growth Regulation: Canopy management through rootstock and scion. Canopy management through plant growth regulators, training and pruning and management practices. Canopy development and management in relation to growth, flowering, fruiting and fruit quality.

VII. Practicals

- Study of different types of canopies (2);
- Training of plants for different canopy types (2);
- Canopy development through pruning (2);
- Understanding bearing behaviour and canopy management in different fruits (2);
- Use of plant growth regulators (2);
- Geometry of planting (1);
- Development of effective canopy with support system (2);
- Study on effect of different canopy types on production and quality of fruits (2).

VIII. Teaching Methods/ Activities

- Class room Lectures
- Laboratory/ Field Practicals
- Student Seminars/ Presentations

- Field Tours/ Demonstrations
- Assignments

IX. Learning outcome

After successful completion of the course, the students are expected to learn

- The basic principles of canopy management to modify plant architecture
- The skills on training and pruning of fruit crops, and growth regulation

X. Suggested Reading

Bakshi JC, Uppal DK and Khajuria HN. 1988. *The Pruning of Fruit Trees and Vines*. Kalyani Publishers, New Delhi.

Chadha KL and Shikhamany SD. 1999. *The Grape, Improvement, Production and Post Harvest Management*. Malhotra Publishing House, Delhi.

Iyer CPA and Kurian RM. 2006. *High Density Planting in Tropical Fruits: Principles and Practices.* IBDC Publishers, New Delhi.

Pradeepkumar T. 2008. *Management of Horticultural Crops*. NIPA, New Delhi.

Singh G. 2010. *Practical Manual on Canopy Management in Fruit Crops.* Dept. of Agriculture and Co-operation, Ministry of Agriculture (GoI), New Delhi.

Srivastava KK. 2012. *Canopy Management in Fruits*. ICAR, New Delhi

I. Course Title : Growth and Development of Fruit Crops

II. Course Code : FSC 507

III. Credit Hours : (2+1)

IV. Why this course ?

The underlying principles and parameters of growth and development needs to be understood for harnessing maximum benefits in term of yield and quality. External environment and inherent hormonal and metabolic pathways

considerably determine growth dynamics. Thus, a course is formulated to develop know-how on physiological and physical aspects of growth and development processes.

V. Aim of the course

To develop comprehensive understanding on growth and development of fruit crops.

The course is structured as under:-

No.	Blocks	Units
1	Introduction	General Concepts and Principles
2	Environment and Development	Climatic Factors, Hormones and Developmental Physiology
3	Stress Management	Strategies for Overcoming Stress

VI. Theory

Block 1: Introduction

Unit I: General Concepts and Principles: Growth and development- definition, parameters of growth and development, growth dynamics and morphogenesis.

Block 2: Environment and Development

Unit I: Climatic Factors, Hormones and Developmental Physiology: Environmental impact on growth and development- effect of light,

temperature, photosynthesis and photoperiodism, vernalisation, heat units and thermoperiodism. Assimilate partitioning, influence of water and mineral nutrition in growth and development; concepts of plant hormone and bioregulators, history, biosynthesis and physiological role of auxins, gibberellins, cytokinins, abscissic acid, ethylene, growth inhibitors and retardant, brasssinosteroids, other New PGRs. Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development.

Block 3: Stress Management

Unit I: Strategies for Overcoming Stress: Growth and developmental process during stress – manipulation of growth and development, impact of pruning and training, chemical manipulations and Commercial application of PGRs in fruit crops, molecular and genetic approaches in plant growth and development.

VII. Practicals

- Understanding dormancy mechanisms in fruit crops and seed stratification (2);
- Techniques of growth analysis (2);
- Evaluation of photosynthetic efficiency under different environments (2);
- Exercises on hormone assays (2);
- Practicals on use of growth regulators (2);
- Understanding ripening phenomenon in fruits (2);
- Study on impact of physical manipulations on growth and development (1);
- Study on chemical manipulations on growth and development (1);

- Understanding stress impact on growth and development (1).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Equipped with understanding of various growth and development processes
- Learned about the role of environment and growth substances
- Acquired the skills to realise optimum growth and development under stress conditions

X. 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, NY, USA.

Dhillon WS and Bhatt ZA. 2011. *Fruit Tree Physiology.* Narendra Publishing House, New Delhi. Durner E. 2013. *Principles of Horticultural Physiology.* CAB International.

NY, USA.

Faust M. 1989. *Physiology of Temperate Zone Fruit Trees*. John Willey & Sons, NY, USA. 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,

New Delhi.

Roberts J, Downs S and Parker P. 2002. Plant Growth Development. In: Salisbury FB and Ross CW. (Eds.) *Plant Physiology*. 4th Ed.Wadsworth Publications, USA.

Schafeer, B. and Anderson, P. 1994. *Handbook of Environmental Physiology of Fruit Crops*.

Vol. 1 & 2. CRC Press. USA.

Seymour GB, Taylor JE and Tucker GA. 1993. *Biochemistry of Fruit Ripening*. Chapman & Hall, London.

I. Course Title : Nutrition of Fruit Crops

II. Course Code : FSC 508

III. Credit Hours : (2+1)

IV. Why this course ?

Nutrients play a significant role in almost every growth and development process determining vigour, yield and quality of fruits. Henceforth, a course is designed to have an in depth study of various nutrients, their uptake and use efficiency in realizing sustainable fruit production

V. Aim of the course

To acquaint with principles and practices involved in nutrition of fruit crops The course is organised as under:-

No.	Blocks	Units
1	Introduction	General Concepts and Principles
2	Requirements and Applications	Diagnostics, Estimation and Application
3	Newer Approaches	Integrated Nutrient Management (INM)

VI. Theory

Block 1: Introduction

Unit I: General Concepts and Principles: Importance and history of nutrition in fruit crops, essential plant nutrients, factors affecting plant nutrition; nutrient uptake and their removal from soil.

Block 2: Requirements and Applications

Unit I: Diagnostics, Estimation and Application: Nutrient requirements, root distribution in fruit crops, soil and foliar application of nutrients in major fruit crops, fertilizer use efficiency. Methods and techniques for evaluating the requirement of macro- and micro-elements, Diagnostic and interpretation techniques including DRIS. Role of different macro- and micro-nutrients, their deficiency and toxicity disorders, corrective measures to overcome deficiency and toxicity disorders.

Block 3: Newer Approaches

Unit I: Integrated Nutrient Management (INM): Fertigation in fruit crops, bio- fertilizers and their use in INM systems.

VII. Practicals

- Visual identification of nutrient deficiency symptoms in fruit crops (2);
- Identification and application of organic, inorganic and bio-fertilizers (1);
- Soil/ tissue collection and preparation for macro- and micro-nutrient analysis (1);
- Analysis of soil physical and chemical properties- pH, EC, Organic carbon (1);
- Determination of N,P,K and other macro- and micronutrients (6);
- Fertigation in glasshouse and field grown horticultural crops (2);
- Preparation of micro-nutrient solutions, their spray and soil applications (2).

I. Teaching Methods/ Activities

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

II. Learning outcome

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

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

III. Suggested Reading

Atkinson D, Jackson JE and Sharples RO. 1980. *Mineral Nutrition of Fruit Trees.* Butterworth – Heinemann.

Bould C, Hewitt EJ and Needham P. 1983. *Diagnosis of Mineral Disorders in Plants Vol.1 Principles.* Her Majesty's Stationery Office, London.

Cooke GW. 1972. *Fertilizers for maximizing yield*. Grenada Publishing Ltd, London.

Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. Wiley Eastern Ltd. Kanwar JS. 1976. *Soil Fertility-Theory and Practice*. ICAR, New Delhi.

Marchner Horst. 1995. *Mineral Nutrition of Higher Plants*, 2nd Ed. Marschner, Academic Press

Inc. San Diego, CA.

Mengel K and Kirkby EA. 1987. *Principles of Plant Nutrition*. 4th Ed. International Potash Institute, Worblaufen-Bern, Switzerland.

Prakash M. 2013. *Nutritional Disorders in Fruit Crops: Diagnosis and Management*. NIPA, New Delhi.

Tandon HLS. 1992. *Management of Nutrient Interactions in Agriculture*. Fertilizer Development and Consultation Organization, New Delhi.

Westerman RL. 1990. *Soil Testing and Plant Analysis*, 3rd Ed. Soil Science Society of America,

Inc., Madison, WI.

Yawalkar KS, Agarwal JP and Bokde S. 1972. *Manures and Fertilizers*. 3rd Ed. Agri Horticultural Publishing House, Nagpur.

I. Course Title : Biotechnology of Fruit Crops

II. Course Code : FSC 509

III. Credit Hours : (2+1)

IV. Why this course ?

In the recent times, biotechnological interventions in fruit crops have

contributed in enhanced yield, biotic and abiotic stress management and improved quality traits to a considerable extent. Hence, a course is designed to educate on the possibilities and progress made through biotechnology for improved fruit production.

V. Aim of the course

To impart knowledge on the principles and tools of biotechnology. Structure of the course is as under:

No.	Blocks	Units
1	General Background Principles	Introduction, History and Basic
2	Tissue Culture	*In-vitro* Culture and Hardening
3	Genetic Manipulation	*In-vitro* Breeding, Transgenics and Gene Technologies

VI. Theory

Block 1: General Background

Unit I: Introduction, History and Basic Principles: Introduction and significance, history and basic principles, influence of explant material, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture.

Block 2: Tissue Culture

Unit I: *In-vitro* Culture and Hardening: Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis; Organ

culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture. Use of bioreactors and *in-vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues. Hardening and *ex vitro* establishment of tissue cultured plants.

Block 3: Genetic Manipulation

Unit I: *In-vitro* Breeding, Transgenics and Gene Technologies: Somatic cell hybridisation, construction and identification of somatic hybrids and cybrids, wide hybridization, *in-vitro* pollination and fertilization, haploids, *in-vitro* mutation, artificial seeds, cryopreservation, *In-vitro* selection for biotic and abiotic stress. Genetic engineering-principles and methods, transgenics in fruit crops, use of molecular markers and genomics. Gene silencing, gene tagging, gene editing, achievements of biotechnology in fruit crops.

VII. Practicals

- An exposure to low cost, commercial and homestead tissue culture laboratories (2);
- Media preparation, Inoculation of explants for clonal propagation, callus induction and culture, regeneration of plantlets from callus (3);
- Sub-culturing techniques on anther, ovule, embryo culture, somaclonal variation (4);
- *In-vitro* mutant selection against abiotic stress (2);
- Protoplast culture and fusion technique (2);
- Development of protocols for mass multiplication (2);
- Project development for establishment of commercial tissue culture laboratory (1).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

After the successful completion of the course, the students are expected to know

- Basic principles and methods of plant tissue culture and other biotechnological tools.
- The use and progress of biotechnology in fruit crops.

X. Suggested Reading

Bajaj YPS. Eds., 1989. *Biotechnology in Agriculture and Forestry*. Vol. V, *Fruits*. Springer, USA.

Brown TA. 2001. *Gene Cloning and DNA Analysis and Introduction.* Blackwell Publishing, USA.

Chahal GS and Gosal SS. 2010. *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches*. Narosa, New Delhi.

Chopra VL and Nasim A. 1990. *Genetic Engineering and Biotechnology – Concepts, Methods and Applications.* Oxford & IBH, New Delhi.

Kale C. 2013. Genome Mapping and Molecular Breeding in Plant, Vol 4. *Fruit and Nuts*.

Springers.

Keshavachandran R and Peter KV. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer*.

Orient & Longman, Universal Press, US.

Keshavachandran R, Nazeem PA, Girija D, John PS and Peter KV. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. Vols. I, II. NIPA, New Delhi.

Litz RE. 2005. *Biotechnology of Fruit and Nut Crops.* CABI, UK.

Miglani GS. 2016. *Genetic Engineering – Principles, Procedures and Consequences*. Narosa Publishing House, New Delhi.

Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK and Mohanadas S. 2001. *Biotechnology of Horticultural Crops*. Vols. I–III. Naya Prokash, Kolkata.

Peter KV. 2013. *Biotechnology in Horticulture: Methods and Applications*. NIPA, New Delhi. Vasil TK, Vasi M, While DNR and Bery HR. 1979. *Somatic Hybridization and Genetic*

Manipulation in Plants. Plant Regulation and World Agriculture. Platinum Press, UK.

I. Course Title : Organic Fruit Culture

II. Course Code : FSC 510

III. Credit Hours : (2+1)

IV. Why this course ?

Considering threats to environment and human health on account of excessive use of chemicals and synthetic fertilizers, organic farming is looked upon as an alternative. Though the organic and other natural farming practices are in evolving phase and are yet to be time scale tested, there is a general perception that these would hold good. As such a course is customised to educate the Graduates on various issues related to organic farming.

V. Aim of the course

To develop understanding on organic production of fruit crops.

No.	Blocks	Units
1	General Aspects	Principles and Current Scenario
2	Organic Culture	Farming System and Practices
3	Certification	Inspection, Control Measures and Certification

VI. Theory

Block 1: General Aspects

Unit I: Principles and Current Scenario: Organic horticulture, scope, area, production and world trade, definition, principles, methods and SWOT analysis.

Block 2: Organic Culture

Unit I: Farming System and Practices: Organic farming systems including biodynamic farming, natural farming, homa organic farming, rishi krishi, EM technology, cosmic farming; on-farm and off-farm production of organic inputs, role of bio-fertilizers, bio enhancers, legumes, inter cropping, cover crops, green manuring, zero tillage, mulching and their role in organic nutrition management. Organic seeds and planting materials, soil health management in organic production, weed management practices in organic farming, biological management of pests and diseases, trap crops, quality improvement in organic production of fruit crops.

Block 3: Certification

Unit I: Inspection, Control Measures and Certification: Inspection and certification of organic produce, participatory guarantee system (PGS), NPOP, documentation and control, development of internal control system (ICS), Concept of group certification, constitution of grower group as per NPOP, preparation of ICS manual, internal and external inspection, concept of third party verification, certification of small farmer groups (Group Certification), transaction certificate, group certificate, critical control points (CCP) and HACCP, IFOAM guidelines on certification scope and chain of custody, certification trademark – The Logo, accredited certification bodies under NPOP. Constraints in certification, IFOAM and global scenario of organic movement, postharvest management of organic produce. Economics of organic fruit production.

VII. Practicals

- Design of organic orchards/ farms management (1);
- Conversion plan (1);
- Nutrient management and microbial assessment of composts and bio-enhancers (2);
- Preparation and application of composts, bio-enhancers and bio-pesticides (2);
- Organic nursery raising (1);
- Application of composts, bio-enhancers, bio-fertilisers and bio-pesticides, green manure, cover, mulching (2);
- Preparation and use of neem based products (1);

- Biodynamic preparations and their role in organic agriculture, EM technology and products, biological/ natural management of pests and diseases (2);
- Soil solarisation (1);
- Frame work for GAP (1);
- Documentation for certification (1).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

On successful completion of the course, the students are expected to be able to

- Familiarize with the concepts and practices of organic and other natural farming systems
- Generate know-how on procedures, policies and regulation for inspection and certification of organic produce

X. Suggested Reading

Claude A. 2004. *The Organic Farming Sourcebook*. Other India Press, Mapusa, Goa, India. Dabholkar SA. 2001. *Plenty for All.* Mehta Publishing House, Pune, Maharashtra.

Das HC and Yadav AK. 2018. *Advances in Organic Production of Fruit Crops.* Westville Publishing House, New Delhi.

Deshpande MS. 2003. *Organic Farming with respect to Cosmic Farming.* Mrs.

Pushpa Mohan Deshpandey, Kolhapur, Maharashtra.

Deshpande WR. 2009. *Basics of Organic Farming*. All India Biodynamic and Organic Farming Association, Indore. MP.

Gaur AC, Neblakantan S and Dargan KS. 1984 *Organic Manures*. ICAR, New Delhi. Lampkin, N. and Ipswich, S. 1990. *Organic Farming*. Farming Press. London, UK.

Lind K, Lafer G, Schloffer K, Innershofer G and Meister H. 2003. *Organic Fruit Growing*. CAB International.

Palaniappan SP and Annadurai K. 2008. *Organic Farming- Theory and Practice*. Scientific Publishers, Jodhpur, Rajasthan, India.

Palekar S. 2004. *The Technique of Spritual Farming*. Chandra Smaritee, Sai Nagar, Amrawati, Maharashtra.

Proctor P. 2008. Biodynamic Farming and Gardening. Other India Press, Mapusa, Goa. Ram RA and Pathak RK. 2017. Bioenhancers. Lap Lambert Academic Publishing, AP.

I. Course Title : Export Oriented Fruit Production

II. Course Code : FSC 511

III. Credit Hours : (2+1)

IV. Why this course ?

India is a top ranking country in production of fruit crops especially with respect mangoes, bananas, and grapes. WTO regime opens new vistas for exploring export opportunities of different fruit commodities. Already, India export mangoes, litchi, grapes, walnuts, apples, etc. and there lies a huge potential in this sector. As such a course has been developed to highlights government policies, standards, infrastructural development and export potential vis-à-vis international scenario.

v. Aim of the course

To acquaints with the national and international standards and export potential of fruit crops

The course is organised as under:-

No.	Blocks	Units
1	Introduction	Statistics and World Trade
2	Regulations	Policies, Norms and Standards
3	Quality Assurance	Infrastructure and Plant Material

VI. Theory

Block 1: Introduction

Unit I: Statistics and World Trade: National and international fruit export and import scenario and trends; Statistics and India's position and potentiality in world trade; export promotion zones in India. Government Policies.

Block 2: Regulations

Unit I: Policies, Norms and Standards: Scope, produce specifications, quality and safety standards for export of fruits, viz., mango, banana, grape, litchi, pomegranate, walnut, apple and other important fruits. Processed and value-added products, post harvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; WTO and its implications, sanitary and phyto-sanitary measures.

Block 3: Quality Assurance

Unit I: Infrastructure and Plant Material: Quality fruit production under protected environment; different types of structures – Automated greenhouses, glasshouse, shade net, poly tunnels – Design and development of low cost greenhouse structures. Seed and planting material; meeting export standards, implications of plant variety protection – patent regimes.

VII. Practicals

- Export promotion zones and export scenario of fresh fruits and their products (1);
- Practical exercises on quality standards of fruits for export purpose (2);
- Quality standards of planting material and seeds (2);
- Hi-tech nursery in fruits (1);
- Practicals on ISO specifications and HACCP for export of fruits (3);
- Sanitary and phyto-sanitary measures during export of horticultural produce (2);
- Post harvest management chain of horticultural produce for exports (2);
- Visit to export oriented units/ agencies like APEDA, NHB, etc.

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- National and international trade scenario of fruit crops
- Set norms and standards for export of fruit crops
- Requisite infrastructure and growing practices meeting export standards

X. Suggested Reading

Chadha KL. 1995. *Advances in Horticulture.* Vol. XII. Malhotra Publ. House, New Delhi.

Chetan GF. 2015. *Export Prospects of Fruits and Vegetables from India: A study of Export market in EU. A project report*. Anand Agricultural University, Anand, Gujarat.

Dattatreylul M. 1997. *Export potential of Fruits, Vegetables and Flowers from India*. NABARD, Mumbai.

Islam, C.N. 1990. *Horticultural Export of Developing Countries: Past Preferences, Future Prospects and Policies*. International Institute of Food Policy Research, USA.

e-Resources

http://apeda.gov.in http://nhb.gov.in http://indiastat.com

I. Course Title : Climate Change and Fruit Crops

II. Course Code : FSC 512

III. Credit Hours : (1+0)

IV. Why this course ?

In the changing climatic scenario, the fruit crops get affected adversely due to one or more unfavourable environmental factors. Shifting of temperate fruits to higher altitudes due to insufficient chilling, occurrence of drought

and frost in warmer areas are notable examples. In order to educate on extent of damage and strategies to mitigate the effect of climate change, a course has been formulated.

V. Aim of the course

To understand the impact of climate change and its management in fruit production. The course is structured as under:-

No.	Blocks	Units
1	General Aspects	Introduction, Global Warming and Climatic Variability
2	Climate Change and Management	Impact Assessment and Mitigation
3	Case Studies	Response to Climate Change

VI. Theory

Block 1: **General Aspects**

Unit I: Introduction, Global Warming and Climatic Variability: Introduction to climate change. Factors directly affecting climate change. Global warming, effect of climate change on spatio-temporal patterns of temperature and rainfall, concentrations of greenhouse gasses in atmosphere. pollution levels such as tropospheric ozone, change in climatic variability and extreme events.

Unit I: Impact Assessment and Mitigation: Sensors for recording climatic parameters, plants response to the climate changes, premature bloom, marginally overwintering or inadequate winter chilling hours, longer growing seasons and shifts in plant hardiness for fruit crops.

Climate mitigation measures through crop management- use of tolerant rootstocks and varieties, mulching – use of plastic-windbreak- spectral changes- protection from frost and heat waves. Climate management in greenhouse- heating – vents – CO_2 injection – screens – artificial light. Impact of climate changes on invasive insect, disease, weed, fruit yield, quality and sustainability. Climate management for control of pests, diseases, quality, elongation of growth and other plant processes- closed production systems.

Block 3: Case Studies

Unit I: Response to Climate Change: Case studies – responses of fruit trees to climatic variability *vis-a-vis* tolerance and adaptation; role of fruit tree in carbon sequestration.

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 are expected to have learnt

- Nature and extent of altered behaviour or damage due to climate change
- Methods to assess the adverse effects
- Approaches to mitigate the effect due to climatic variability

IX. Suggested Reading

Dhillon WS and Aulakh PS. 2011. *Impact of Climate Change in Fruit Production*. Narendra Publishing House, New Delhi.

Peter KV. 2008. *Basics in Horticulture*. New India Publishing Agency, New Delhi.

Ramirez F and Kallarackal J. 2015. *Responses of Fruit Trees to Global Climate Change*. Spinger- Verlag.

Rao GSLHV. 2008. *Agricultural Meteorology*. Prentice Hall, New Delhi.

Rao GSLHV, Rao GGSN, Rao VUM and Ramakrishnan YS. 2008. *Climate Change and Agriculture over India*. ICAR, New Delhi.

Schafeer B and Anderson P. 1994. *Handbook of Environmental Physiology of Fruit Crops*.Vol. 1 & 2. CRC Press. USA.

I. Course Title : Minor Fruit Production

II. Course Code : FSC 513

III. Credit Hours : (2+1)

IV. Why this course ?

Apart from commercially grown fruits, several other fruits inspite of being rich in nutrients and potential future crops, remains neglected/ underexploited. The hardy nature coupled with the possibility of diversification (newly domesticated crops) further adds to their importance. The course outlines the efforts made in standardizing agro-techniques for propagation and cultivation besides know-how on their nutraceutical value and other uses.

V. Aim of the course

To import basic knowledge underexploited minor fruit crops. The course is structured as under:-

No.	Blocks	Units
1	Introduction	Occurrence, Adoption and General Account
2	Agro-Techniques	Propagation and Cultural Practices
3	Marketing and utilization	Post-Harvest Management

VI. Learning outcome

On successful completion of the course, the students are expected to know about

- Various minor fruits hitherto neglected and their commercial value
- Efforts made to domesticate minor fruits and standardization of agro-techniques.
- Their utilization in processing industry.

VII. Theory

Block 1: Introduction

Unit I: Occurrence, Adoption and General Account: Importance – occurrence and distribution, climate adaptation in fragile ecosystem and wastelands.

Block 2: Agro-Techniques

Unit I: Propagation and Cultural Practices: Traditional cultural practices and recent development in agro-techniques; propagation, botany-floral biology, growth patterns, mode of pollination, fruit set, ripening, fruit quality.

Block 3: Marketing and Utilization

Unit I: Post-Harvest Management: Post harvest management, marketing; minor fruit crops in terms of medicinal and antioxidant values; their uses for edible purpose and in processing industry

Crops

Bael, chironji, fig, passion fruit, jamun, phalsa, karonda, woodapple, cactus pear, khejri, kair, pilu, lasoda, loquat, tamarind, dragon fruit, monkey jack, mahua, khirni, amra, kokum, cape gooseberry, kaphal, persimmon, pistachio, seabuckthorn, hazel nut and other minor fruits of regional importance

VIII. Practicals

- Visits to institutes located in the hot and cold arid regions of the country (2);
- Identification of minor fruits plants/ cultivars (2);
- Collection of leaves and preparation of herbarium (1);
- Allelopathic studies (2);
- Generating know-how on reproductive biology of minor fruits (4);
- Fruit quality attributes and biochemical analysis (3);
- Project formulation for establishing commercial orchards in fragile ecosystems (1).

Course Title with Credit Load

M.Sc. (Hort.) in Vegetable Science

Course Code	Course Title	Credit Hours
	Major Courses (20 Credits)	
VSC 501*	Production of Cool Season Vegetable Crops	2+1
VSC 502*	Production of Warm Season Vegetable Crops	2+1
VSC 503*	Growth and Development of Vegetable Crops	2+1
VSC 504*	Principles of Vegetable Breeding	3+0
VSC 505	Breeding of Self Pollinated Vegetable Crops	2+1
VSC 506	Breeding of Cross Pollinated Vegetable Crops	2+1
VSC 507	Protected Cultivation of Vegetable Crops	1+1
VSC 508	Seed Production of Vegetable Crops	2+1
VSC 509	Production of Underutilized Vegetable Crops	2+1

VSC 510	Systematics of Vegetable Crops	1+1
VSC 511	Organic Vegetable Production	1+1
VSC 512	Production of Spice Crops	2+1
VSC 513	Processing of Vegetable	1+1
VSC 514	Postharvest Management of Vegetable Crops	2+1
	Minor Courses	08
	Supporting Courses	06
	Common compulsory courses	05
VSC 591	Seminar	0+1
VSC 599	Research	0+30
	Total Credits	**70**

*Compulsory among major courses

Course Contents

M.Sc. (Hort.) in Vegetable Science

I. Course Title : Production of Cool Season Vegetable Crops

II. Course Code : VSC 501

III. Credit Hours : (2+1)

IV. Why this course ?

Cool season vegetables are a major source of dietary fibres, minerals and vitamins. Some of these vegetables also contribute protein, fat and carbohydrate. Most of the leafy and root vegetables are rich in minerals, especially in micro-elements such as copper, manganese and zinc. Vegetables differ in their temperature requirement for proper growth and development. Most of the winter vegetable crops are cultivated in cool season when the monthly mean temperature does not exceed 21°C. Even in temperate climate, these vegetables are cultivated in spring summer in hilly tracks where the daytime temperature in summer is less than 21°C. The students of vegetable science need to have an understanding of production technology of important cool season vegetable crops and their management.

V. Aim of the course

To impart knowledge and skills on advancement in production technology of cool season vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Production of cool season vegetable crops	I Bulb and tuber crops
		II Cole crops
		III Root crops
		IV Peas and beans
		V Leafy vegetables

VI. Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery, sowing/ planting time and methods,hrydroponics and aeroponics, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of crops.

Unit I

Bulb and tuber crops—Onion, garlic and potato.

Unit II

Cole crops—Cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and kale.

Unit III

Root crops—Carrot, radish, turnip and beetroot.

Unit IV

Peas and beans—Garden peas and broad bean.

Unit V

Leafy vegetables—Beet leaf, fenugreek, coriander and lettuce.

VII. Practical

- Scientific raising of nursery and seed treatment;
- Sowing and transplanting;
- Description of commercial varieties and hybrids;
- Demonstration on methods of irrigation, fertilizers and micronutrients application;
- Mulching practices, weed management;
- Use of plant growth substances in cool season vegetable crops;
- Study of nutritional and physiological disorders;
- Studies on hydroponics, aeroponics and other soilless culture;
- Identification of important pest and diseases and their control;
- Preparation of cropping scheme for commercial farms;
- Visit to commercial farm, greenhouse/ polyhouses;
- Visit to vegetable market;
- Analysis of benefit to cost ratio.

VIII. Teaching Methods/ Activities

- Classroom lectures
- Assignment (written and speaking)

- Student presentation
- Hands on training of different procedures
- Group discussion

IX. Learning outcome

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

- Appreciate the scope and scenario of cool season vegetable crops in India
- Acquire knowledge about the production technology and post-harvest handling of cool season vegetable crops
- Calculate the economics of vegetable production in India

X. Suggested Reading

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya udyog.

Bose TK, Som MG and Kabir J. (Eds.). 1993. *Vegetable crops*. Naya prokash.

Chadha KL and Kalloo G. (Eds.). 1993-94. *Advances in horticulture* Vols. V-X. Malhotra publ. house.

Chadha KL. (Ed.). 2002. *Hand book of horticulture*. ICAR.

Chauhan DVS. (Ed.). 1986. *Vegetable production in India*. Ram prasad and sons.

Fageria MS, Choudhary BR and Dhaka RS. 2000. *Vegetable crops: production technology*. Vol. II. Kalyani publishers.

Gopalakrishanan TR. 2007. *Vegetable crops*. New India publ. agency.

Hazra P and Banerjee MK and Chattopadhyay A. 2012. *Varieties of vegetable crops in India*, (Second edition), Kalyani publishers, Ludhiana, 199 p.

Hazra P. 2016. *Vegetable Science*. 2nd edn, Kalyani publishers, Ludhiana.

Hazra P. 2019. *Vegetable production and technology*. New India publishing agency, New Delhi.

Hazra P, Chattopadhyay A, Karmakar K and Dutta S. 2011. *Modern technology for vegetable production*, New India publishing agency, New Delhi, 413p

Rana MK. 2008. *Olericulture in India*. Kalyani publishers, New Delhi.

Rana MK. 2008. *Scientific cultivation of vegetables*. Kalyani publishers, New Delhi. Rana MK. 2014. *Technology for vegetable production*. Kalyani publishers, New Delhi.

Rubatzky VE and Yamaguchi M. (Eds.). 1997. *World vegetables: principles, production and nutritive values*. Chapman and Hall.

Saini GS. 2001. *A text book of oleri and flori culture*. Aman publishing house.

Salunkhe DK and Kadam SS. (Ed.). 1998. Hand book of vegetable science and technology: production, composition, storage and processing. Marcel dekker.

Shanmugavelu KG. 1989. *Production technology of vegetable crops*. Oxford and IBH.

Singh DK. 2007. *Modern vegetable varieties and production technology*. International book distributing Co.

Singh SP. (Ed.). 1989. *Production technology of vegetable crops*. Agril. comm. res. centre. Thamburaj S and Singh N. (Eds.), 2004. *Vegetables, tuber crops and spices*. ICAR. Thompson HC and Kelly WC. (Eds.). 1978. *Vegetable crops*. Tata McGraw-Hill.

I. **Course Title : Production of Warm Season Vegetable Crops**

II. **Course Code : VSC 502**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Unlike cool-season vegetables, warm-season vegetable crops require higher soil and air temperature, thus, they are always planted after the last frost date ranging from late spring after the last frost date to late summer. Daytime temperature may still be warm enough but drop so much at night-time that the weather is not suitable for warm-season crops any longer. In general summer vegetables require a little higher temperature than winter vegetables for optimum growth. In summer vegetables, the edible portion is mostly botanical fruit. The students of vegetable science need to have an understanding of production technology of important warm season vegetable crops and thereafter their management.

V. Aim of the course

To impart knowledge and skills on advancement in production technology of warm season vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Production of warm season vegetable crops	1. Fruit vegetables 2. Beans 3. Cucurbits

4. Tuber crops

5. Leafy vegetables

VI. Theory

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery including grafting technique, sowing/ planting time and methods, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices namely hydroponics, aeroponics, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marking), pest and disease management and economics of crops.

Unit I

Fruit vegetables—Tomato, brinjal, hot pepper, sweet pepper and okra.

Unit II

Beans—French bean, Indian bean (Sem), cluster bean and cowpea.

Unit III

Cucurbits—Cucumber, melons, gourds, pumpkin and squashes.

Unit IV

Tuber crops—Sweet potato, elephant foot yam, tapioca, taro and yam.

Unit V

Leafy vegetables—Amaranth and drumstick.

VII. Practical

- Scientific raising of nursery and seed treatment;
- Sowing, transplanting, vegetable grafting;
- Description of commercial varieties and hybrids;
- Demonstration on methods of irrigation, fertilizers and micronutrients application;
- Mulching practices, weed management;
- Use of plant growth substances in warm season vegetable crops;
- Study of nutritional and physiological disorders;
- Studies on hydroponics, aeroponics and other soilless culture;
- Identification of important pest and diseases and their control;
- Preparation of cropping scheme for commercial farms;
- Visit to commercial farm, greenhouse/ polyhouses;
- Visit to vegetable market;
- Analysis of benefit to cost ratio.

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Appreciate the scope and scenario of warm season vegetable crops in India
- Acquire knowledge about the production technology and post-harvest handling of warm season vegetable crops
- Calculate the economics of vegetable production in India

Suggested Reading

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya udyog.

Bose TK, Som MG and Kabir J. (Eds.). 1993. *Vegetable crops*. Naya prokash.

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Hazra P. 2019. *Vegetable production and technology*. New India publishing agency, New Delhi.

Hazra P, Chattopadhyay A, Karmakar K and Dutta S. 2011. *Modern technology for vegetable production*, New India publishing agency, New Delhi, 413p

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Saini GS. 2001. *A text book of oleri and flori culture*. Aman publishing house.

Salunkhe DK and Kadam SS. (Ed.). 1998. *Hand book of vegetable science and technology: production, composition, storage and processing*. Marcel dekker.

Shanmugavelu KG., 1989. *Production technology of vegetable crops*. Oxford and IBH.

Singh DK. 2007. *Modern vegetable varieties and production technology*. International book distributing Co.

Singh SP. (Ed.). 1989. *Production technology of vegetable crops*. Agril. comm. res. centre. Thamburaj S and Singh N. (Eds.). 2004. *Vegetables, tuber crops and spices*. ICAR. Thompson HC and Kelly WC. (Eds.). 1978. *Vegetable crops*. Tata McGraw-Hill.

I. Course Title : Growth and Development of Vegetable Crops

II. Course Code : VSC 503

III. Credit Hours : (2+1)

IV. Why this course ?

In agriculture, the term plant growth and development is often substituted with crop growth and yield since agriculture is mainly concerned with crops and their economic products. Growth, which is irreversible quantitative increase in size, mass, and/ or volume of a plant or its parts, occurs with an expenditure of metabolic energy. Plant development is an overall term, which refers to various changes that occur during its life cycle. In vegetable crops, development is a series of processes from the initiation of growth to death of a plant or its parts. Growth and development are sometimes used interchangeably in conversation, but in a botanical sense, they describe separate events in the organization of the mature plant body. The students of vegetable science need to have an understanding of growth and development of vegetable crops.

V. Aim of the course

To teach the physiology of growth and development of vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Growth and development of crops	1. Introduction and phytohormones vegetable 2. Physiology of dormancy and germination 3. Abiotic factors 4. Fruit physiology 5. Morphogenesis and tissue culture

VI. Theory

Unit I

Introduction and phytohormones—Definition of growth and development; Cellular structures and their functions; Physiology of phyto-hormones functioning/ biosynthesis and mode of action; Growth analysis and its importance in vegetable production.

Unit II

Physiology of dormancy and germination—Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellilns, cyktokinins and abscissic acid; Application of synthetic PGRs including plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production.

Unit III

Abiotic factors—Impact of light, temperature, photoperiod, carbon dioxide, oxygen and other gases on growth, development of underground parts, flowering and sex expression in vegetable crops; Apical dominance.

Unit IV

Fruit physiology—Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening.

Unit V

Morphogenesis and tissue culture—Morphogenesis and tissue culture techniques in vegetable crops; Grafting techniques in different vegetable crops.

VII. Practical

- Preparation of plant growth regulator's solutions and their application;
- Experiments in breaking and induction of dormancy by chemicals;
- Induction of parthenocarpy and fruit ripening;
- Application of plant growth substances for improving flower initiation, changing sex expression in cucurbits and checking flower and fruit drops and improving fruit set in solanaceous vegetables;
- Growth analysis techniques in vegetable crops;
- Grafting techniques in tomato, brinjal, cucumber and sweet pepper.

VIII. Teaching Methods/ Activities

- Classroom Lectures
- Assignment (written and speaking)

- Student presentation
- Hands on training of different procedure
- Group discussion

IX. Learning outcome

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

- Acquire knowledge about the growth and development of plants in vegetable crops
- Distinguish between primary and secondary growth in plant stems
- Understand how hormones affect the growth and development of vegetable crops

X. Suggested Reading

Bleasdale JKA. 1984. *Plant physiology in relation to horticulture* (2nd Edition) MacMillan. Gupta US. Eds. 1978. *Crop physiology*. Oxford and IBH, New Delhi. Kalloo G. 2017. *Vegetable grafting: Principles and practices*. CAB International Krishnamoorti HN. 1981. *Application growth substances and their uses in agriculture*. Tata

McGraw Hill, New Delhi.

Leopold AC and Kriedemann PE. 1981. *Plant growth and development*, Tata McGraw-Hill, New Delhi.

Peter KV and Hazra P. (Eds). 2012. *Hand book of vegetables*.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.

Peter KV. (Eds). 2008. *Basics of horticulture*. New India publication agency, New Delhi. Rana MK. 2011. *Physio-biochemistry and Biotechnology of Vegetables*. New India Publishing

Agency, Pritam Pura, New Delhi.

Saini *et al.* (Eds.). 2001. *Laboratory manual of analytical techniques in horticulture*. Agrobios, Jodhpur.

Wien HC. (Eds.). 1997. *The physiology of vegetable crops*. CAB International.

I. Course Title : Principles of Vegetable Breeding

II. Course Code : VSC 504

III. Credit Hours : (2+1)

IV. Why this course ?

Plant breeding has been practiced for thousands of years, since beginning of human civilization. Vegetable breeding, which is an art and science of changing the traits of plants in order to produce desired traits, has been used to improve the quality of nutrition in products for human beings. A breeding programme, which is needed if current varieties are not producing up to the capacity of the environment, can be accomplished through many different techniques ranging from simply selecting plants with desirable characteristics, make use of knowledge of genetics and chromosomes to more complex molecular techniques. When different genotypes exhibit differential responses to different sets of environmental conditions, a genotype x environment (GxE) interaction is said to occur. Breeding high yielding open pollinated varieties and hybrids, and exploitation of location specific component of genotypic performance are the only options left to reduce this increasing gap between the production and requirements in view of decreasing land resources. Noevertheless, vegetable breeding is an integral part of plant breeding but this will

be re-modeled to suit to breeding of different vegetables crops. The students of vegetable science who are having breeding as major subject need to have an understanding of vegetable breeding principles.

V. Aim of the course

To teach basic principles and practices of vegetable breeding.

The course is constructed given as under:

No.	Block	Unit
1.	Principles of vegetable breeding	I. Importance and history
		II. Selection procedures
		III. Heterosis breeding
		IV. Mutation breeding
		V. Polyploid breeding
		VI. Ideotype breeding

VI. Theory

Unit I

Importance and history- Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding.

Unit II

Selection procedures- Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture; Breeding for biotic stress (diseases, insect pests and nematode), abiotic stress (temperature, moisture and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE).

Unit III

Heterosis breeding- Types, mechanisms and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility and sex forms.

Unit IV

Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable

crops and vegetables suitable for protected environment.

Unit V

Ideotype breeding- Ideotype breeding; varietal release procedure; DUS testing in vegetable crops; Application of *In-vitro* and molecular techniques in vegetable improvement.

VII. Practical

- Floral biology and pollination behaviour of different vegetables;
- Techniques of selfing and crossing of different vegetables, viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, etc.;
- Breeding system and handling of filial generations of different vegetables;
- Exposure to biotechnological lab practices;
- Visit to breeding farms.

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Acquire knowledge about the principles of vegetable breeding
- Improve yield, quality, abiotic and biotic resistance, other important traits of vegetable crops
- Understand how the basic principles are important to start breeding of vegetable crops

X. Suggested Reading

Allard RW. 1960. *Principle of plant breeding*. John Willey and Sons, USA. Kalloo G. 1988. *Vegetable breeding* (Vol. I, II, III). CRC Press, Fl, USA.

Kole CR. 2007. *Genome mapping and molecular breeding in plants-vegetables*. Springer, USA. Peter KVand Pradeep Kumar T. 1998. Genetics and breeding of vegetables. ICAR, New Delhi, p. 488.

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I. **Course Title : Breeding of Self-Pollinated Vegetable Crops**

II. **Course Code : VSC 505**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Self-pollination, which is considered the highest degree of inbreeding a plant can achieve, promotes homozygosity of all gene loci and traits of the sporophyte and restricts the creation of new gene combinations (no introgression of new genes through hybridization). The progeny of a single plant is homogeneous due to self pollination. A population of self-pollinated species comprises a mixture of homozygous lines. New genes may arise through mutation but such change is restricted to individual lines or the progenies of the mutant plant. Since a self-pollinated cultivar is generally one single genotype reproducing itself, breeding of self-pollinated species usually entails identifying one superior genotype (or a few) and its multiplication. Specific breeding methods commonly used for self-pollinated species are pure- line selection, pedigree breeding, bulk populations and backcross breeding. The students of vegetable science who take breeding as a minor subject need to have an understanding of breeding of self pollinated vegetable crops.

V. Aim of the course

To impart comprehensive knowledge about principles and practices of breeding of self pollinated vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Breeding of self pollinated vegetable crops	I. Potato II. Fruit vegetables III. Garden peas and cowpea IV. Beans V. Leafy vegetables

VI. Theory

Origin, botany, taxonomy, wild relatives, cytogenetics and genetics, types of pollination and fertilization mechanism, sterility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation and polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stresses, breeding for protected environment and quality improvement, molecular markers and marker's assisted breeding; QTLs, PPV and FR Act.

Unit I

Tuber crops: Potato.

Unit II

Fruit vegetables- Tomato, eggplant, hot pepper, sweet pepper and okra.

Unit III

Leguminous vegetables- Garden peas and cowpea.

Unit IV

Leguminous vegetables: French bean, Indian bean, cluster bean and broad bean.

Unit V

Leafy vegetables- Lettuce and fenugreek.

VII. Practical

- Floral mechanisms favouring self and often cross pollination;
- Progeny testing and development of inbred lines;
- Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations;
- Palynological studies, selfing and crossing techniques;
- Hybrid seed production of vegetable crops in bulk;
- Screening techniques for biotic and abiotic stress resistance in above mentioned crops;
- Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques;
- Visit to breeding farms;

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Acquire knowledge about the breeding of self pollinated vegetable crops
- Improve yield, quality, abiotic and biotic resistance and other important traits of vegetable crops
- Understand how to start the breeding of self pollinated vegetable crops

x. Suggested Reading

Allard RW. 1999. *Principles of plant breeding*. John Wiley and Sons.

Basset MJ. (Ed.). 1986. *Breeding vegetable crops*. AVI Publ.

Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005, Plant genetic resources: horticultural crops. Narosa Publ. House.

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Swarup V. 1976. *Breeding procedure for cross-pollinated vegetable crops*. ICAR.

I. **Course Title : Breeding of Cross Pollinated Vegetable Crops**

II. **Course Code : VSC 506**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

The important methods of breeding in cross-pollinated vegetable species are (i) mass selection, (ii) development of hybrid varieties and (ii) development of synthetic varieties. Since cross-pollinated vegetable crops are naturally hybrid (heterozygous) for many traits and lose vigour as they become purebred (homozygous), a goal of each of these breeding methods is to preserve or restore heterozygosity in cross pollinated vegetable crops. The students of vegetable science who take breeding as a minor subject need to have an understanding of breeding of cross pollinated vegetable crops.

V. Aim of the course

To impart comprehensive knowledge about principles and practices of cross pollinated vegetable crops breeding.

The course is constructed given as under:

No.	Block	Unit
1.	Breeding of cross pollinated vegetable crops	I. Cucurbitaceous crops II. Cole crops III. Root and bulb crops IV. Tuber crops V. Leafy vegetables

VI. Theory

Origin, botany, taxonomy, cytogenetics, genetics, types of pollination and fertilization, mechanism, sterility and incompatibility, breeding objectives, breeding methods (introduction, selection, hybridization, mutation, polyploidy), varieties and varietal characterization, resistance breeding for biotic and abiotic stresses, quality improvement, molecular markers and marker assisted breeding, and QTLs, PPV and FR act

Unit I

Cucurbitaceous crops—Gourds, melons, cucumber, pumpkin and squashes.

Unit II

Cole crops—Cauliflower, cabbage, kohlrabi, broccoli and brussels sprouts.

Unit III

Root and bulb crops—Carrot, radish, turnip, beet root and onion.

Unit IV

Tuber crops—Sweet potato, tapioca, taro and yam.

Unit V

Leafy vegetables—Beet leaf, spinach, amaranth and coriander.

VII. Practical

- Floral mechanisms favouring cross pollination;
- Development of inbred lines;
- Selection of desirable plants from breeding population;
- Observations and analysis of various quantitative and qualitative traits in germplasm, hybrids and segregating generations;
- Induction of flowering, palynological studies, selfing and crossing techniques;
- Hybrid seed production of vegetable crops in bulk; Screening techniques for biotic and abiotic stress resistance in above mentioned crops;

- Demonstration of sib-mating and mixed population;
- Molecular marker techniques to identify useful traits in vegetable crops and special breeding techniques;
- Visit to breeding blocks.

VIII. Teaching Methods/ Activities

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation individual or in group
- Hands on training of different procedures
- Group discussion

IX. Learning outcome

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

- Acquire knowledge about the breeding of cross pollinated vegetable crops
- Improve yield, quality, abiotic and biotic resistance, and important traits of cross pollinated vegetable crops
- Understand how to start the breeding of cross pollinated vegetable crops

X. Suggested Reading

Allard RW. 1999. *Principles of plant breeding*. John Wiley and Sons. Basset MJ. (Ed.). 1986. *Breeding vegetable crops*. AVI Publ.

Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. *Plant genetic resources: horticultural crops*. Narosa publ. house.

Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable crops: breeding and seed production*.

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Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.

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Hazra P and Som MG. 2016. *Vegetable seed production and hybrid technology* (Second revised edition), Kalyani Publishers, Ludhiana, 459 p

Kalloo G. 1988. *Vegetable breeding*. Vols. I-III. CRC Press.

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Singh PK, Dasgupta SK and Tripathi SK. 2004. *Hybrid vegetable development*. International book distributing Co.

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I. Course Title : Protected Cultivation of Vegetable Crops

II. Course Code : VSC 507

III. Credit Hours: (2+1)

IV. Why this course ?

India is the second largest producer of vegetable crops in the world. However, its vegetable production is much less than the requirement, if a balanced diet is provided to every individual. There are different ways and means to achieve this target. Protected cultivation, which is the modification of the natural environment to achieve optimum

plant growth. Is the most intensive form of crop production with a yield per unit area up to ten times superior to that of a field crop. During winter under north-east Indian conditions, it is difficult to grow tomato, capsicum, cucurbits, french bean, amaranth, etc. in open field. However, various types of protected structure have been developed for growing some high value crops by providing protection from the excessive cold. Production of off-season vegetable nurseries under protected structure has become a profitable business. The main purpose of raising nursery plants in protected structure is to get higher profit and disease free seedlings in off-season to raise early crop in protected and open field condition. The low cost polyhouse is economical for small and marginal farmers, who cannot afford huge cost of high-tech polyhouse. Besides supplying the local markets, the production of polyhouse vegetables is greatly valued for its export potential and plays an important role in the foreign trade balance of several national economies. The students of vegetable science need to have an understanding of protected cultivation of vegetable crops.

V. Aim of the course

To impart latest knowledge about growing of vegetable crops under protected environmental conditions

The course is constructed given as under:

No.	Block	Unit
1.	Protected cultivation of vegetable crops	I. Scope and importance II. Types of protected structure III. Abiotic factors IV. Nursery raising V. Cultivation of crops VI. Solutions to problems

VI. Theory

Unit I

Scope and importance- Concept, scope and importance of protected cultivation of vegetable crops; Principles, design, orientation of structure, low and high cost polyhouses/ greenhouse structures.

Unit II

Types of protected structure- Classification and types of protected structures- greenhouse/ polyhouses, plastic-non plastic low tunnels, plastic walk in tunnels, high roof tunnels with ventilation, insect proof net houses, shed net houses, rain shelters, NVP, climate control greenhouses, hydroponics and aeroponics; Soil and soilless media for bed preparation; Design and installation of drip irrigation and fertigation system.

Unit III

Abiotic factors- Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity, etc. on growth and yield of different vegetables.

Unit IV

Nursery raising- High tech vegetable nursery raising in protected structures using plugs and portrays, different media for growing nursery under protected cultivation; Nursery problems and management technologies including fertigation.

Unit V

Cultivation of crops- Regulation of flowering and fruiting in vegetable crops; Technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, including varieties and hybrids, training, pruning and staking in growing vegetables under protected structures.

Unit VI

Solutions to problems- Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for seed production; Economics of greenhouse crop production.

VII. Practical

- Study of various types of protected structure;
- Study of different methods to control temperature, carbon dioxide and light;
- Study of different types of growing media, training and pruning systems in greenhouse crops;
- Study of fertigation and nutrient management under protected structures;
- Study of insect pests and diseases in greenhouse and its control;
- Use of protected structures in hybrid seed production of vegetables;
- Economics of protected cultivation (Any one crop);

- Visit to established green/ polyhouses/ shade net houses in the region.

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Appreciate the scope and scenario of protected cultivation of vegetable crops in India
- Acquire knowledge about the effect of abiotic factors on growth, flowering and production of vegetable crops
- Gaining knowledge about the designing of various low cost protected structures
- Adopting the raising of vegetable seedlings in low cost protected structures as entrepreneur

X. Suggested Reading

Chadha KL and Kalloo G. (Eds.). 1993-94. *Advances in horticulture*. Malhotra Pub. House. Chandra S and Som V. 2000. *Cultivating vegetables in green house*. Indian horticulture 45:17-18.

Kalloo G and Singh K. (Eds.). 2000. *Emerging scenario in vegetable research and development*.Research periodicals and Book publ. house.

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I. Course Title : Seed Production of Vegetable Crops

II. Course Code : VSC 508

III. Credit Hours : (2+1)

IV. Why this course ?

Enhancing yield and quality of vegetable crops depends upon a number of factors. The inputs like fertilizers, irrigation and plant protection measures and suitable agronomic practices contribute greatly towards improving yield and quality of the vegetable produce. If good quality seed is not used, the full benefits of such inputs and agronomic practices can not be realized. The use of high quality seed thus, plays a pivotal role in the production of vegetable crops. It is, therefore, important to use the seed conforming to the prescribed standards. A good quality seed should have high genetic and physical purity, proper moisture content and good germination. It should also be free from seed borne diseases and weed seeds. The quality of the produce will deteriorate if these factors are overlooked. Out crossing, physical admixtures and mutations are the prime factors responsible for the deterioration of seed quality. A variety could be saved from deterioration if proper checks are made at different stages of seed multiplication. It is also extremely important to maintain high genetic purity of a variety. The students of vegetable science need to have an understanding of seed production technology of vegetable crops and their essential processing before supplying them to the market or further use.

V. Aim of the course

To impart a comprehensive knowledge and skills on quality seed production of vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Seed production of vegetable crops	I. Introduction, history, propagation and reproduction II. Agro-climate and methods of seed production III. Seed multiplication and its quality maintenance IV. Seed harvesting, extraction and its processing V. Improved agro-techniques and field and seed standards

VI. Theory

Unit I

Introduction, history, propagation and reproduction—Introduction, definition of seed and its quality, seed morphology, development and maturation; Apomixis and fertilization; Modes of propagation and reproductive behaviour; Pollination mechanisms and sex forms in vegetables; History of vegetable seed production; Status and share of vegetable seeds in seed industry.

Agro-climate and methods of seed production—Agro-climate and its influence on quality seed production; Deterioration of crop varieties, genetical and agronomic principles of vegetable seed production; Methods of seed production, hybrid seeds and techniques of large scale hybrid seed production; Seed village concept

Unit III

Seed multiplication and its quality maintenance—Seed multiplication ratios and replacement rates in vegetables; Generation system of seed multiplication; Maintenance and production of nucleus, breeder, foundation, certified/ truthful label seeds; Seed quality and mechanisms of genetic purity testing

Unit IV

Seed harvesting, extraction and its processing—Maturity standards; Seed harvesting, curing and extraction; Seed processing, viz., cleaning, drying and treatment of seeds, seed health and quality enhancement, packaging and marketing; Principles of seed storage; Orthodox and recalcitrant seeds; Seed dormancy

Unit V

Improved agro-techniques and field and seed standards—Improved agro-techniques; Field and seed standards in important solanaceous, leguminous and cucurbitaceous vegetables, cole crops, leafy vegetables, bulbous and root crops and okra; clonal propagation and multiplication in vegetative propagated crops; Seed plot technique and true potato seed production in potato

VII. Practical

- Study of floral biology and pollination mechanisms in vegetables;
- Determination of modes of pollination;
- Field and seed standards;
- Use of pollination control mechanisms in hybrid seed production of important vegetables;
- Maturity standards and seed extraction methods;

- Seed sampling and testing;
- Visit to commercial seed production areas;
- Visit to seed processing plant;
- Visit to seed testing laboratories.

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Appreciate the scope and scenario of seed production of vegetable crops in India
- Acquire knowledge about the complete seed production technology, extraction and post-extraction processing of vegetable seeds
- Adoption of seed production of vegetable crops as entrepreneur

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Agrawal PK and Dadlani M. (Eds.). 1992. *Techniques in seed science and technology*. South asian Publ.

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Bench ALR and Sanchez RA. 2004. *Handbook of seed physiology*. Food products press, NY/ London.

Bendell PE. (Eds.). 1998. *Seed science and technology: Indian forestry species*. Allied Publ. Chakraborty SK, Prakash S, Sharma SP and Dadlani M. 2002. *Testing of distinctiveness, uniformity and stability for plant variety protection*. IARI, New Delhi

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More TA, Kale PB and Khule BW. 1996. *Vegetable seed production technology*. Maharashtra state seed corp.

Rajan S and Markose BL. 2007. *Propagation of horticultural crops*. New India publ. agency. Singh NP, Singh DK, Singh YK and Kumar V. 2006. *Vegetable seed*

production technology.

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Singh SP. 2001. *Seed production of commercial vegetables*. Agrotech publ. academy.

Singhal NC. 2003. *Hybrid seed production*. Kalyani publishers, New Delhi

I. Course Title : Production of Underutilized Vegetable Crops

II. Course Code : VSC 509

III. Credit Hours : (2+1)

IV. Why this course ?

With increasing population and fast depletion of natural resources, it has become essential to explore the possibilities of using newer indigenous plant resources. Underutilized crops are plant species that are used traditionally by the country people for their food, fibre, fodder, oil, or medicinal properties but have yet to be adopted by large scale agriculturalists. In general, underutilized plants constitute those plant species that occur as life support species in extreme environmental conditions and threatened habitats, having genetic tolerance to survive under harsh conditions and possess qualities of nutritional and/ or industrial importance for a variety of purposes. Underutilized crops are those plant species with under-exploited potential for contributing to food security, health (nutritional or medicinal), income generation and environmental services. Once the underutilized food crops are properly utilized, they may help to contribute in food security, nutrition, health, income generation and environmental services. The underutilized crops can be defined as the crops, which being region specific are less available, less utilized or rarely used. These underutilized crop species have also been described as *rare*, *minor*, *orphan*, *promising* and little-used vegetable crops. The students of vegetable science need to have an understanding of production technology of underutilized vegetable crops.

V. Aim of the course

To impart knowledge about production technology of lesser utilized vegetable crops The course is constructed given as under:

No.	Block	Unit
1.	Production of underutilized vegetable crops	I. Stem and bulb crops II. Cole and salad crops III. Gourds and melons IV. Leafy vegetables V. Yams and beans

VI. Theory

Importance and scope, botany and taxonomy, climate and soil requirement, commercial varieties/ hybrids, improved cultural practices, physiological disorders, harvesting and yield, plant protection measures and post harvest management of:

Unit I

Stem and bulb crops—Asparagus, leek and chinese chive

Unit II

Cole and salad crops—Red cabbage, chinese cabbage, kale, sweet corn and baby corn

Unit III

Leafy vegetables—Celery, parsley, indian spinach (poi), spinach, chenopods, chekurmanis and indigenous vegetables of regional importance

Unit IV

Gourds and melons—Sweet gourd, spine gourd, teasle gourd, round gourd, and little/ Ivy gourd, snake gourd, pointed gourd, kachri, long melon, snap melon and gherkin

Unit V

Yam and beans—Elephant foot yam, yam, yam bean, lima bean and winged bean

VII. Practical

- Identification and botanical description of plants and varieties;
- Seed/ planting material;
- Production, lay out and method of planting;
- Important cultural operations;
- Identification of important pests and diseases and their control;
- Maturity standards and harvesting;
- Visit to local farms.

Teaching Methods/ Activities

- Delivering of lectures by power point presentation
- Assignment (written and speaking)
- Student presentation
- Hands on training of different procedures
- Group discussion

Learning outcome

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

- Appreciate the scope and scenario of production of underutilized vegetable crops in India
- Acquire knowledge about the production technology of underutilized vegetable crops

- Adopting production of lesser utilised crops as entrepreneur

Suggested Reading

Bhat KL. 2001. *Minor vegetables-untapped potential*. Kalyani publishers, New Delhi.

Indira P and Peter KV. 1984. *Unexploited tropical vegetables*. Kerala agricultural university, Kerala.

Pandey AK. 2011. *Aquatic vegetables.* Agrotech publisher academy, New Delhi.

Peter KV. (Eds.). 2007-08. *Underutilized and underexploited horticultural crops*. Vol.1-4, New India publishing agency, Lucknow.

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Rana MK. 2018. *Vegetable crop science*. CRC Press Taylor and Francis Group 6000 Broken Sound Parkway NW, Suite 300 Boca Raton, FL 33487-2742 ISBN: 978-1-1380-3521-8

Rubatzky VE and Yamaguchi M. 1997. *World vegetables: vegetable crops*. NBPGR, New Delhi.

I. **Course Title : Systematics of Vegetable Crops**

II. **Course Code : VSC 510**

III. **Credit Hours : (1+1)**

IV. **Why this course ?**

Systematics is fundamental to our understanding of the world around us as it provides basis for understanding the patterns of diversity on earth. Vegetable systematics is the science of botanical diversity of vegetable crops on earth, including variation from the level of genes within an individual to individuals, populations and species. The primary aim of systematics is to discover all the branches of the tree of life, document evolutionary changes occurring along those branches, and describe all the species on earth (the tips of the branches). The secondary aim of systematic is to analyze and synthesize information into a classification that reflects evolutionary relationships, to organize this information into a useful, retrievable form to gain insight into evolutionary processes that lead to diversity.

V. Aim of the course

To impart knowledge on morphological, cytological and molecular taxonomy of vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Systematics of vegetable crops	I. Significance of systematics
		II. Origin and evolution
		III. Botanical and morphological description
		IV. Cytology

VI. Theory

Unit I

Significance of systematic—Significance of systematics and crop diversity in vegetable crops; Principles of classification; different methods of classification; Salient features of international code of nomenclature of vegetable crops

Unit II

Origin and evolution—Origin, history, evolution and distribution of vegetable crops

Unit III

Botanical and morphological description—Botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables; Morphological keys to identify important families, floral biology, floral formula and diagram; Morphological description of all parts of vegetables

Unit IV

Cytology—Cytological level of various vegetable crops with descriptive keys

Unit V

Molecular markers—Importance of molecular markers in evolution of vegetable crops; Molecular markers as an aid in characterization and taxonomy of vegetable crops

VII. Practical

- Identification, description, classification and maintenance of vegetable species and varieties;
- Survey, collection of allied species and genera locally available;
- Preparation of keys to the species and varieties;

- Methods of preparation of herbarium and specimens.

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Acquire knowledge on identification, description, classification and maintenance of vegetable species and varieties
- Collecting locally available allied species of vegetable crops
- Preparing herbarium and specimens

X. Suggested Reading

Chopra GL. 1968. *Angiosperms- systematics and life cycle*. S. Nagin Dutta AC. 1986. *A class book of botany*. Oxford Univ. Press.

Pandey BP. 1999. *Taxonomy of angiosperm*. S. Chand and Co

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Vasistha. 1998. *Taxonomy of angiosperm*. Kalyani Publishers, New Delhi.

Vincent ER and Yamaguchi M. 1997. *World vegetables*. 2nd Ed. Chapman and Hall.

I. **Course Title : Organic Vegetable Production**

II. **Course Code : VSC 511**

III. **Credit Hours : (1+1)**

IV. **Why this course ?**

Organic vegetable farming is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. Organic farming has been simply defined as a production system working in partnership with nature to produce vegetable crops. The current trend towards increasing popularity of organically produced vegetables is relatively new. The objective of organic farming is to produce safer food and to keep the environment healthy. During the decade of nineties, the interest in organic farming began to creep into the mainstream consumer purchases. Currently, it appears to be an influx of business oriented producers into the organic production field. The increasing popularity of organic food among the elite societies is due to the belief that food produced with this system is free of pesticides and has greater nutritive value than conventionally produced food. The students of vegetable science need to have an understanding of organic vegetable farming technology.

V. Aim of the course

To elucidate principles, concepts and their applications in organic farming of vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Organic vegetable production	1. Importance and principles

2. Organic production of vegetables
3. Managing soil fertility
4. Composting methods
5. Certification and export

VI. Theory

Unit I

Importance and principles—Importance, principles, perspective, concepts and components of organic farming in vegetable crops

Unit II

Organic production of vegetables—Organic production of vegetable crops, viz., Solanaceous, Cucurbitaceous, Cole, root and tuber crops

Unit III

Managing soil fertility—Managing soil fertility, mulching, raising green manure

crops, weed management in organic farming system; Crop rotation in organic production; Processing and quality control of organic vegetable produce

Unit IV

Composting methods—Indigenous methods of composting, Panchyagavvya, Biodynamics preparations and their application; ITKs in organic vegetable farming; Role of botanicals and bio-control agents in the management of pests and diseases in vegetable crops

Unit V

Certification and export—Techniques of natural vegetable farming, GAP and GMP- certification of organic products; Export- opportunity and challenges

VII. Practical

- Methods of preparation and use of compost, vermicompost, biofertilizers and biopesticides;
- Soil solarisation;
- Use of green manures;
- Waste management; Organic soil amendments in organic production of vegetable crops;
- Weed, pest and disease management in organic vegetable production;
- Visit to organic fields and marketing centres.

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Appreciate the scope and scenario of organic vegetable production in India
- Acquire knowledge about the organic vegetable production technology
- Adopting production of organic vegetable crops a s entrepreneur

X. Suggested Reading

Dahama AK. 2005. *Organic farming for sustainable agriculture*. 2nd Ed. Agrobios.

Gehlot G. 2005. *Organic farming; standards, accreditation certification and inspection*. Agrobios. Palaniappan SP and Annadorai K. 2003. *Organic farming, theory and practice*. Scientific publ.

Pradeepkumar T, Suma B, Jyothibhaskar and Satheesan KN. 2008.

Management of horticultural crops. New India Publ. Agency.

Shivashankar K. 1997. *Food security in harmony with nature. 3rd IFOAMASIA,* Scientific Conf. 1- 4 December, UAS, Bangalore.

I. **Course Title : Production of Spice Crops**

II. **Course Code : VSC 512**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Spices are an important part of human history and played an important role in the development of most cultures around the world. Spice may be a seed, fruit, root, bark, or any other plant substance primarily used for flavouring, colouring, or preserving food. Spices are distinguished from herbs, which are the leaves, flowers, or stems of plants used for flavouring or as a garnish. Many spices have antimicrobial properties, because of which why spices are more commonly used in warmer climates, which have more infectious diseases, and use of spices is prominent in meat, which is predominantly susceptible to spoiling. The students of vegetable science need to have an understanding of production technology of spices and their processing before supplying them to the market or further use.

V. Aim of the course

To impart basic knowledge about the importance and production technology of spices grown in India

The course is constructed given as under:

No.	Block	Unit
1.	Production of spice crops	1. Fruit spices 2. Bud and kernel spices 3. Underground spice crops 4. Seed spices 5. Tree spices

VI. Theory

Introduction and importance of spice crops- historical accent, present status (national and international), future prospects, botany and taxonomy, climatic and soil requirement, commercial cultivars/ hybrids, site selection, layout, sowing/ planting time and methods, seed rate and seed treatment, nutritional and irrigation requirement, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures, quality control and pharmaceutical significance of crops mentioned below:

Unit I

Fruit spices- Black pepper, small cardamom, large cardamom and allspice

Unit II

Bud and kernel- Clove and nutmeg

Unit III

Underground spices- Turmeric, ginger and garlic

Unit IV

Seed spices- Coriander, fenugreek, cumin, fennel, ajowain, dill and celery

Unit V

Tree spices- Cinnamon, tamarind, garcinia and vanilla

VII. Practical

- Identification of seeds and plants;
- Botanical description of plant;
- Preparation of spice herbarium;
- Propagation;
- Nursery raising;

- Field layout and method of planting;
- Cultural practices;
- Harvesting, drying, storage, packaging and processing;
- Value addition;
- Short term experiments on spice crops.

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Appreciate the scope and scenario of production of spice crops in India
- Acquire knowledge about the production technology and processing of spice crops
- Adopting production of spice crops as entrepreneur

X. Suggested Reading

Agarwal S, Sastry EVD and Sharma RK. 2001. *Seed spices: production, quality, export*. Pointer Publication.

Arya PS. 2003. *Spice crops of India*. Kalyani.

Bhattacharjee SK. 2000. *Hand book of aromatic plants*. Pointer publications.

Bose TK, Mitra SK, Farooqi SK and Sadhu MK. (Eds.). 1999. *Tropical horticulture*.Vol.I. Naya Prokash.

Chadha KL and Rethinam P. (Eds.). 1993. *Advances in horticulture*. Vols. IX-X. *Plantation crops and spices*. Malhotra Publ. House.

Gupta S. (Ed.). *Hand book of spices and packaging with formulae*. engineers India research institute, New Delhi.

Kumar NA, Khader P, Rangaswami and Irulappan I. 2000. *Introduction to spices, plantation crops, medicinal and aromatic plants*. Oxford and IBH.

Nybe EV, Miniraj N and Peter KV. 2007. *Spices*. New India Publ. Agency.

Parthasarthy VA, Kandiannan V and Srinivasan V. 2008. *Organic spices*. New India Publ.

Agency.

Peter KV. 2001. *Hand book of herbs and spices*. Vols. I-III. Woodhead Publ. Co. UK and CRC USA.

Pruthi JS. (Ed.). 1998. *Spices and condiments*. National Book Trust

Pruthi JS. 2001. *Minor spices and condiments- crop management and post harvest technology*.

ICAR.

Purseglove JW, Brown EG, Green CL and Robbins SRJ. (Eds.). 1981. *Spices*. Vols. I, II. Longman.

Shanmugavelu KG, Kumar N and Peter KV. 2002. *Production technology of spices and plantation crops*. Agrobios.

Thamburaj S and Singh N. (Eds.). 2004. *Vegetables, tuber crops and spices*. ICAR.

Tiwari RS and Agarwal A. 2004. *Production technology of spices*. International Book Distr. Co. Varmudy V. 2001. *Marketing of spices*. Daya Publ. House.

I. Course Title : Processing of Vegetable Crops

II. Course Code : VSC 513

III. Credit Hours : (1+1)

IV. Why this course ?

In India, agriculture is the basis of economy. Agricultural industries and related activities, which can be termed as agriculturally based vegetable processing, can account for a considerable proportion of their output. Both established and planned vegetable processing projects aim at solving a very clearly identified developmental problems. The growers sustain substantial losses due to insufficient demand in the market, weak infrastructure, poor transportation and perishable nature of the vegetable crops. During the postharvest glut, the loss is considerable and often some of the produce are fed to the animals or allowed to decay. Even the established vegetable canning industries or small/ medium scale processing centres suffer huge loss due to erratic supplies since the growers like to sell their produce in the open market directly to the consumers, or the produce may not be of enough high quality to process but it might be good enough for the table use, meaning that processing is seriously underexploited. The main objective of vegetable processing is to supply wholesome, safe, nutritious and acceptable food to the consumers throughout the year. Vegetable processing also aims to replace imported products like squash, jams, tomato sauces, pickles, etc., besides earning foreign exchange by exporting finished or semi-processed products. The students of vegetable science need to have an understanding of vegetable processing.

V. Aim of the course

To educate the students about the principles and practices of processing in vegetable crops

The course is constructed given as under:

No.	Block	Unit
1.	Processing of vegetable crops	I Present status
		II Spoilage and biochemical changes
		III Processing equipments
		IV Quality control
		V Value addition

VI. Theory

Unit I

Present status—Present status and future prospects of vegetable preservation industry in India

Unit II

Spoilage and biochemical changes—Spoilage of fresh and processed vegetable produce; biochemical changes and enzymes associated with spoilage of vegetable produce; Principal spoilage organisms, food poisoning and their control measures; Role of microorganisms in food preservation

Unit III

Processing equipments—Raw material for processing; Primary and minimal

processing; Processing equipments; Layout and establishment of processing industry; FPO licence; Importance of hygiene; Plant sanitation

Unit IV

Quality control—Quality assurance and quality control, TQM, GMP; Food standards- FPO, PFA, etc.; Food laws and regulations; Food safety- hazard analysis and critical control points (HACCP); Labeling and labeling act and nutrition labeling

Unit V

Value addition—Major value added vegetable products; Utilization of byproducts of vegetable processing industry; Management of processing industry waste; Investment analysis; Principles and methods of sensory evaluation of fresh and processed vegetables

VII. Practical

- Study of machinery and equipments used in processing of vegetable produce;
- Chemical analysis for nutritive value of fresh and processed vegetable;
- Study of different types of spoilage in fresh as well as processed vegetable produce;
- Classification and identification of spoilage organisms;
- Study of biochemical changes and enzymes associated with spoilage;
- Laboratory examination of vegetable products;
- Sensory evaluation of fresh and processed vegetables;
- Study of food standards- National, international, CODEX Alimentarius;
- Visit to processing units to study the layout, hygiene, sanitation and waste management.

VIII. Teaching Methods/ Activities

- Classroom Lectures

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

IX. Learning outcome

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

- Appreciate the scope and scenario of vegetable processing in India
- Acquire knowledge about the processing technology of vegetable crops
- Adopting processing products of vegetable crops at small or medium scale
- Adopt processing of vegetable crops as entrepreneur

X. Suggested Reading

Arthey D and Dennis C. 1996. *Vegetable processing*. Blackie/ Springer-Verlag. Chadha DS. 2006. *The Prevention of food adulteration act*. Confed. of Indian Industry. Desrosier NW. 1977. *Elements and technology*. AVI Publ. Co.

FAO. 1997. *Fruit and Vegetable processing*. FAO.

FAO. *CODEX Alimentarius: Joint FAO/ WHO food standards programme*. 2nd Ed. Vol. VB.

tropical fresh fruits and vegetables. FAO.

FAO. *Food quality and safety systems- training manual on food hygiene and haccp*.

FAO. Fellow's P. 1988. Food processing technology. Ellis Horwood International.

Frazier WC and Westhoff DC. 1995. *Food microbiology*. 4th Ed. Tata McGraw Hill.

Giridharilal GS Siddappa and Tandon GL. 1986, *Preservation of fruits and vegetables*. ICAR. Gisela J. 1985. *Sensory evaluation of food- theory and practices*. Ellis Horwood.

Graham HD. 1980. *Safety of foods*. AVI Publ. Co.

Hildegrade H and Lawless HT. 1997. *Sensory evaluation of food*. CBS. Joslyn M

and Heid *Food processing operations*.AVI Publ. Co.

Mahindru SN. 2004. *Food safety: concepts and reality*. APH Publ. Corp.

Ranganna S. 1986. *Handbook of analysis and quality control for fruit and vegetable products*. 2nd Ed. Tata-McGraw Hill.

Shapiro R. 1995. *Nutrition labeling handbook.* Marcel Dekker.

Srivastava RP and Kumar S. 2003. *Fruit and vegetable preservation: principles and practices*.3rd Ed. International Book Distri. Co.

Tressler and Joslyn MA. 1971. *Fruit and vegetable juice processing technology*. AVI Publ. Co. Verma LR and Joshi VK. 2000. *Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management*. Indus Publ. Co.

I. **Course Title : Postharvest Management of Vegetable Crops**

II. **Course Code : VSC 514**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Vegetables are highly perishable crops as they have great quantity and quality loss after harvest. Hence, they require integrated approach to arrest their spoilage, which causes tonnes of vegetable produce annually. Lack of postharvest awareness and inadequacy of equipments are the major problems in postharvest chain, which lead to a serious post-harvest loss in the developing countries every year. A comprehensive understanding of postharvest factors causing deterioration is necessary to overcome these challenges. Pre and postharvest management such as use of improved varieties, good cultural practices, good pre and postharvest handling practices, management of temperature, relative humidity and storage atmosphere according to crop requirement, use of permitted chemicals, design of appropriate packaging material and storage structures are some of the control measures used in reducing postharvest losses, therefore, this course was customized.

V. Aim of the course

To facilitate deeper understanding of principles and to acquaint the student with proper handling and management technologies of vegetable crops for minimizing the post-harvest losses

The course is organized as follows:

No.	Blocks	Units

1.	Post-harvest management of vegetable crops	I Importance and scope II Maturity indices and biochemistry III Harvesting and losses factors IV Packinghouse operations V Methods of storage

VI. Theory

Unit I

Importance and scope—Importance and scope of post-harvest management of vegetables

Unit II

Maturity indices and biochemistry—Maturity indices and standards for different vegetables; Methods of maturity determination; Biochemistry of maturity and ripening; Enzymatic and textural changes; Ethylene evolution and ethylene management; Respiration and transpiration along with their regulation methods

Unit III

Harvesting and losses factors—Harvesting tools and practices for specific market requirement; Postharvest physical and biochemical changes; Preharvest practices and other factors affecting postharvest losses.

Unit IV

Packing house operations—Packing house operations; Commodity pretreatments chemicals, wax coating, precooling and irradiation; Packaging of vegetables, prevention from infestation, management of postharvest diseases and principles of transportation

Unit V

Methods of storage—Ventilated, refrigerated, modified atmosphere and controlled atmosphere storage, hypobaric storage and cold storage; Zero-energy cool chamber, storage disorders like chilling injury in vegetables

VII. Practical

- Studies on stages and maturing indices;
- Ripening of commercially important vegetable crops;
- Studies of harvesting, pre-cooling, pre-treatments, physiological disorders- chilling injury;
- Improved packaging;
- Use of chemicals for ripening and enhancing shelf life of vegetables;
- Physiological loss in weight, estimation of transpiration, respiration rate and ethylene release;
- Storage of important vegetables;
- Cold chain management;
- Visit to commercial packinghouse, cold storage and control atmosphere storage.

VIII. Teaching Methods/ Activities

- Classroom lectures including ppt.
- Students group discussion
- Individual or group assignments (writing and speaking)
- Presentation of practical handwork

IX. Learning outcome

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

- Regulation of postharvest losses by using chemicals and growth regulators
- Pre and postharvest treatments for extending shelf life of vegetable crops
- Packinghouse operations for extending the shelf life of vegetable crops
- Successful storage of vegetable crops

X. Suggested Reading

Chadha KL and Pareek OP. 1996. *Advances in horticulture*. Vol. IV. Malhotra Publ. House. Chattopadhyay SK. 2007. *Handling, transportation and storage of fruit and vegetables*. Gene-

Tech books, New Delhi.

Haid NF and Salunkhe SK. 1997. *Postharvest physiology and handling of fruits and vegetables*.

Grenada Publ.

Mitra SK. 1997. *Postharvest physiology and storage of tropical and sub-tropical fruits*. CABI. Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest biology and technology of*

Fruits, vegetables and flowers. Wiley-Blackwell, ISBN: 9780813804088.

Ranganna S. 1997. *Handbook of analysis and quality control for fruit and vegetable products*.

Tata McGraw-Hill.

Stawley JK. 1998. *Postharvest physiology of perishable plant products*. CBS publishers. Sudheer KP and Indira V. 2007. *Postharvest technology of horticultural crops*. New India Publ.

Agency.

2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.

Verma LR and Joshi VK. 2000. *Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.

Willis R, McGlassen WB, Graham D and Joyce D. 1998. *Postharvest: An introduction to the physiology and handling of fruits, vegetables and ornamentals*. CABI.

Wills RBH and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.

Wills RBH and Golding J. 2017. *Advances in postharvest fruit and vegetable technology*, CRC Press, ISBN 9781138894051.

HorticulturalSciences

– Floriculture and Landscaping

Indian floriculture which remained homestead farming till late 80's assumed commercial

significance during 90's owing to the favourable environment created by a series of reforms in economy and seed sector. This has paved the way for the import of new plant material, introduction of protected cultivation technology in the country. The area under flower crops got almost tripled from 1,06,000 ha during 2001–02 to 3,39,000 ha during 2018–19. Similar trend was also noticed in production of flowers in India with an overall production of 19.91 lakh tonnes. India's total export of floriculture was ₹ 571.38 Crores/ 81.94 USD Millions in 2018–19. The major importing countries were United States, Netherlands, United Kingdom, Germany and United Arab Emirates.

Contrary to belief, floriculture encompasses a large number of sub sectors that include loose flowers, cut flowers, cut foliage, specialty flowers, cut greens and fillers, pot plants, bedding plants, landscaping and interiorscaping, vertical gardening, dry flowers, lawns, arboriculture, essential oils, nutraceutical pigments, dyes, value addition, etc., Keeping in pace with the latest developments in these sectors, there is a need to update the knowledge among the students. An effort is therefore made to encompass the advances made in the sector by revising the post-graduate curriculum.

New courses like Systematics of ornamental plants; Indoor plants and Interioscaping, Nursery Management of ornamental plants; Turf grass management; Seed production in flower crops; Crop regulation in ornamental crops; Speciality flowers, fillers and cut greens; Vertical gardening; Modern approaches in breeding of floricultural crops; Current trends in production of floricultural crops; Recent developments in protected cultivation of floricultural crops are introduced in the new syllabus while retaining some of the old courses.

Keeping in view of the National Initiatives and priorities like Skill India and emphasis on StartUps to encourage students to become job creators rather than job seekers, new courses are added in different avenues of floriculture like Indoor plants and Interioscaping, Nursery management, Turfgrass management, Vertical gardening. These courses will help and encourage students to develop their skills and would pave way

for different StartUps in these areas.

New courses like seed production in flower crops, Crop regulation in ornamental crops, Specialty flowers, fillers and cut greens are introduced in line with requirement to improve profitability of farmers/ growers. Seed production in flowers which is a high value, low volume segment was focussed upon which will boost our exports and help in improving profitability and improving farmers income. Crop regulation is an important aspect and need of the hour to avoid market glut, improve profitability and income of growers.

Rapid changes and development have occurred in global arena particularly in the field of biochemistry, molecular biology and biotechnology. Many advances took place in the area of application of biotechnology approaches in flower crops. A segment on genome editing systems/ tools like CRISPR-CAS is introduced into the syllabus keeping in view of the recent developments. Several new developments in the area of protected cultivation like automation, sensors, lighting, AI, robotics, retractable greenhouses, IPR, flower labels, etc. are given due emphasis in the new syllabus.

Flowers are highly perishable and fluctuation of prices is very high and marketing is a very crucial step where growers and entrepreneurs face problems. Topics on marketing, Agri export Zones, value chain and cold chain management and crop insurance were given importance. Government of India has introduced a number of schemes and mechanisms to support the farming community. To make the students aware about the recent steps taken by Government, topic on Institutional support is introduced. Farming community is rapidly diversifying in to areas like FPO's and contract farming and these areas are introduced.

Course Title with Credit Load

M.Sc. (Hort.) in Floriculture and Landscaping

Course Code	Course Title	Credit Hours
	Major Courses (20 Credits)	
FLS 501*	Systematics of Ornamental Plants	2+1
FLS 502*	Breeding of Ornamental Plants	2+1
FLS 503*	Commercial Production of Cut Flowers	2+1
FLS 504*	Commercial Production of Loose Flowers	2+1
FLS 505*	Ornamental Gardening and Landscaping	2+1
FLS 506	Indoor Plants and Interiorscaping	1+1
FLS 507	Nursery Management in Ornamental Plants	2+1
FLS 508	Turf Grass Management	2+1
FLS 509	Value Addition in Floriculture	2+1
FLS 510	Protected Cultivation of Flower Crops	2+1
FLS 511	CAD for Landscaping	1+2
FLS 512	Seed Production in Flower Crops	1+1
	Minor Courses	08
	Supporting Courses	06
	Common compulsory courses	05
FLS 591	Seminar	0+1
FLS 599	Research	0+30
	Total Credits	**70**

*Compulsory among major courses

Course Contents

M.Sc. (Hort.) in Floriculture and Landscaping

I. **Course Title : Systematics of Ornamental Plants**

II. **Course Code : FLS 501**

III. **Credit Hours : (1+1)**

IV. **Why this course ?**

Systematics of ornamental plants will give an in depth knowledge on nomenclature, description of genera, floral biology and use of molecular techniques in systematics of flower crops and ornamental crops.

V. Aim of the course

To familiarize students about the taxonomy, classification, nomenclature and descriptors of different ornamental crops.

The course is organized as follows

No	Blocks	Units
1	Nomenclature	Unit 1: History, origin, hotspots, classification and nomenclature systems Unit 2: International Code, Identification features, descriptors. Unit 3: Red Book, Registration with NBPGR, PPVFRA
2	Families	Unit 1: Rosaceae, Asteraceae,

		Caryophyllaceae, Orchidaceae, Aracaeae, Liliacaeae, Unit 2: Acanthaceae, Palmaceae, Asparagaceae, Malvaceae, Musaceae, Oleaceae, Iridaceae.
3	Molecular techniques systematics.	Unit 1: Molecular techniques in modern

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VI. Theory

Block I: Nomenclature

Unit I: Nomenclature: History, origin, hotspots, classification and nomenclature systems.

Unit II: International systems: International Code, Treaties, International and National Organisations, Biodiversity Act, Identification features, descriptors.

Unit III: Red Book, Registration (NBPGR, PPVFRA, NBA).

Block 2: Families

Unit I: Families: Description and families and important genera Rosaceae, Asteraceae, Caryophyllaceae, Orchidaceae, Aracaceae, Liliacae.

Unit II: Acanthaceae, Palmaceae, Asparagaceae, Malvaceae, Musaceae, Oleaceae, Iridaceae.

Block 3: Molecular techniques

Unit I: Molecular techniques in modern systematics.

VII. Practical

- Different nomenclature systems of plants (2);
- Floral biology and taxonomic description of rose, chrysanthemum, orchids, carnation, gerbera, anthurium, marigold, tuberose, Jasmine, China aster, lilium, gypsophila (6);
- Cyropreservation and tissue culture repository (4);
- Molecular techniques (4).

VIII. Teaching Methods/ Activities

- Lectures
- Group discussions
- Flip classes
- Assignment and student presentation
- Hands on training of different procedures

IX. Learning outcome

After successful completion of this course,

- The students will have an in depth knowledge of nomenclature, description of important genera and use of molecular techniques in systematics of flower crop

X. Suggested Reading

Bhattacharya B and Johri BM. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Publ.

House, New Delhi, India. pp.753.

Dutta AC. 1986. *A Class Book of Botany*. Oxford Univ. Press, Kolkata, India.

Pandey BP. 2013. *Taxonomy of Angiosperms*. S. Chand & Co. pp. 608.

Rajput CBS and Haribabu RS. 2014. *Citriculture*, Kalyani Publishers, New Delhi, India.

Spencer RR, Cross R and Lumley P. 2007. *Plant Names*. 3rd Ed. *A Guide to Botanical*

Nomenclature. CSIRO Publ., Australia., 176 p.

Vasistha BB. 1998. *Taxonomy of Angiosperms*. Kalyani Publishers, New Delhi, India.

I. **Course Title : Breeding of Ornamental Crops**

II. **Course Code : FLS 502**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Breeding novel and desired varieties is very important for growth of floriculture Industry. Students should have a thorough understanding of principles of plant breeding, genetic mechanisms and breeding methods in ornamental crops for making improvement in these crops.

V. Aim of the course

To impart comprehensive knowledge about the principles and practices of breeding of ornamental plants.

The course is organized as follows:

No	Blocks	Units
1	Principles of Plant Breeding	I. Principles of plant breeding II. Intellectual Property and Plant Breeders Rights III. Genetic mechanisms and inheritance
2	Breeding methods	I. Breeding methods II. Role of biotechnology

VI. Theory

Block 1: Principles of Plant Breeding

Unit I: Principles of plant breeding: Principles of plant breeding; Origin, evolution, distribution, introduction, domestication and conservation of ornamental crops.

Unit II: Intellectual Property and Plant Breeders Rights: Introduction and initiatives in IPR and PBR of ornamental crops.

Unit III: Genetic mechanisms and inheritance: Breeding objectives, reproductive barriers (Male sterility, incompatibility) in major ornamental crops. Inheritance of important traits, Genetic mechanisms associated with flower colour, size, form, doubleness, fragrance, plant architecture, post-harvest life, abiotic and biotic stress tolerance/ resistance.

Block 2: Breeding methods

Unit I: Breeding methods: Breeding methods suitable for sexually, asexually propagated flower crops, self and cross pollinated crops- pedigree

selection, backcross, clonal selection, polyploidy and mutation breeding, heterosis and F1 hybrids.

Unit II: Role of biotechnology: Role of biotechnology in improvement of flower crops including somaclonal variation, *in-vitro* mutagenesis, *in-vitro* selection, genetic engineering, molecular markers, etc.

Crops

Rose, chrysanthemum, carnation, gerbera, gladiolus, orchids, anthurium, lilium, marigold, jasmine, tuberose, dahlia, gaillardia, crossandra, aster, etc., Flowering annuals: petunia, zinnia, snapdragon, stock, pansy, calendula, balsam, dianthus, etc. Important ornamental crops like aglaonema, diffenbachia, hibiscus, bougainvillea, kalanchoe, etc.

VII. Practical

- Floral biology of important ornamental crops (2);
- Cytology and cytogenetics (2);
- Selfing and crossing procedures for important ornamental crops (2);
- Evaluation of hybrid progenies (2);
- Induction of mutants through physical and chemical mutagens (2);
- *In-vitro* selection, genetic engineering (2);
- Induction of polyploidy (2);
- DUS testing (2).

VIII. Teaching Methods/ Activities

- Lectures
- Group discussions
- Flip classes
- Assignment and student presentation
- Hands on training of different procedures

IX. Learning outcome

After successful completion of course, the students are expected to have

- Thorough understanding of principles of plant breeding and genetic mechanisms in different ornamental plants and flowers.
- Application of different breeding methods for improvement of ornamental crops
- Develop the required skills in conventional and advanced breeding

X Suggested Reading

Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Pointer Publ., Reprint, 6 vols,

pp. 2065.

Bose TK and Yadav LP. 1989. *Commercial flowers.* Naya Prokash, Kolkata, India.

Callaway DJ and Callaway MB. 2009. *Breeding Ornamental Plants*. Timber Press. Revised edition, pp. 359.

Chadha KL and Bhattacharjee SK. 1995. *Advances in Horticulture: Ornamental Plants.* Vol.

XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India.

Chadha KL and Choudhury B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.

Chaudhary RC. 1993. *Introduction to Plant Breeding.* Oxford & IBH Publ.

Misra RL and Misra S. 2017. *Commercial Ornamental Crops: Cut Flowers*. Kruger Brentt Publisher UK Ltd. pp.584.

Misra RL and Misra S. 2017. *Commercial Ornamental Crops: Traditional and Loose Flowers*.

Kruger Brentt Publisher UK Ltd.

Singh BD. 2016. *Plant Breeding Principles and Methods*. Kalyani Publishers, New Delhi- Ludhiana, India.

Vainstein A. (Ed). 2002. *Breeding for ornamental crops: Classical and Molecular Approaches*.

Springer-Science-Business Media, B.V. Edition 1. pp. 392.

Watts L. 1980. *Flower and Vegetable Plant Breeding*. Unilever Research, Sharnbrook, Bedford, UK. pp 182. Grower Books, London, UK.

I. Course Title : Commercial Production of Cut Flowers

II. Course Code : FLS 503

III. Credit Hours : (2+1)

IV. Why this course ?

Cut flowers are grown in a wide variety of environments and agroclimatic regions. The students of floriculture need to have an understanding of production and post harvest management of important cut flower crops on a commercial scale.

V. Aim of the course

To impart basic knowledge about the importance and production dynamics of cut flowers grown in India.

The course is organized as follows

No	Blocks	Units
1	Production management	I. Scope and scenario
		II. Growing environment
		II. Crop Management
		III. Flower regulation
2	Post harvest management and	I. Post harvest management marketing
		II. Marketing

VI. Theory

Block 1: Production management

Unit I: Scope and scenario: National and International scenario, importance and scope of cut flower trade, constraints for cut flower production in India.

Unit II: Growing environment: Soli analysis, soil health card, Growing environment, open cultivation, protected cultivation, soil/ media requirements, land preparation, planting methods, influence of light, temperature, moisture, humidity and microclimate management on growth and flowering.

Unit III: Crop management: Commercial Flower production – Commercial varieties, water and nutrient management, fertigation, weed management, crop specific practices, ratooning, training and pruning, pinching, deshooting, bending, desuckering, disbudding. Use of growth regulators, physiological disorders and remedies, IPM and IDM.

Unit IV: Flower regulation: Flower forcing and year round/ offseason flower production through physiological interventions, chemical regulation, environmental manipulation.

Block 2: Post-harvest management and marketing

Unit I: Post harvest management: Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, storage and transportation.

Unit II: Marketing: Marketing, export potential, institutional support, Agri Export Zones, 100% Export Oriented units, Crop Insurance.

Crops

Rose, chrysanthemum, gladiolus, tuberose, carnation, gerbera, orchids, lilium, anthurium, china aster, alstroemeria, bird of paradise, heliconia, alpinia, ornamental ginger, dahlia, gypsophila, solidago, limonium, stock, cut greens and fillers.

VII. Practical

- Identification of varieties (1);
- Propagation (2);
- Microclimate management (2);
- Training and pruning techniques (1);
- Pinching, deshooting, disbudding, desuckering (1);
- Practices in manuring, drip and fertigation, foliar nutrition, growth regulator application (2);

- Harvesting techniques, post-harvest handling, cold chain (2);
- Economics, Project preparation for regionally important cut flowers, crop specific guidelines for project financing (NHB guidelines) (2);
- Visit to commercial cut flower units (2);
- Case studies (1).

VIII. Teaching Methods/ Activities

- Lectures
- Group discussions
- Flip classes
- Assignment and student presentation
- Hands on training of different procedures
- Exposure visits

IX. Learning outcome

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

- Understand the scope and scenario of floriculture
- A thorough understanding of production and post harvest management of flower crops.
- Acquire the required skills to prepare project reports on different crops for financing.

X. Suggested Reading

Arora JS. 2010. *Introductory Ornamental Horticulture*. Kalyani Publishers. 6th edition, pp.

230.

Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Reprint, pp. 2065.

Bose TK, Maiti, RG, Dhua RS and Das P. 1999. *Floriculture and Landscaping*. Prokash, Kolkata, India.

Bose TK and Yadav LP. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.

Chadha KL and Bhattacharjee SK. 1995. *Advances in Horticulture: Ornamental Plants*. Vol.

XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India.

Chadha KL and Chaudhury B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.

Dole JM and Wilkins HF. 2004. *Floriculture-Principles and Species*. Prentice Hall. 2nd edition,

pp. 1048.

Larson RA. 1980. *Introduction to Floriculture*. New York Academic Press. pp. 628.

Laurie A and Rees VH. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publications, Jodhpur. pp.534.

Prasad S and Kumar U. 2003. *Commercial Floriculture*. Agrobios Publications, Jodhpur. Randhawa GS and Mukhopadhyay A. 2001. *Floriculture in India*. Allied Publ. pp 660.

Reddy S, Janakiram T, Balaji Kulkarni S and Misra RL. 2007. *Hi- Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi, India.

Singh AK. 2006. *Flower Crops: Cultivation and Management.* New India Publ. Agency, New Delhi, India. pp. 475.

I. Course Title : Commercial Production of Loose Flowers

II. Course Code : FLS 504

III. Credit Hours : (2+1)

IV. Why this course ?

Loose flowers are grown in a wide range of agroclimatic regions. The students of floriculture need to have an understanding of production and post harvest management of important loose flower crops.

V. Aim of the course

To impart basic knowledge about the importance and management of loose flowers grown in India.

The course is organized as follows

No	Blocks	Units
1	Production management	I. Scope and scenario II. Growing environment III. Crop management IV. Flower regulation
2	Post harvest management and marketing	I. Post harvest management II. Marketing

VI. Theory

Block 1: Production management

Unit I: Scope and scenario: Scope, scenario and importance of loose flowers, constraints and opportunities in loose flower production.

Unit II: Growing environment: Nursery management, pro-tray nursery under shade nets, soil and climate requirement, Field preparation, systems of planting.

Unit III: Crop management: Soli analysis, soil health card, water and nutrient management, weed management, training and pruning, special horticultural practices such as pinching and disbudding, use of growth regulators, physiological disorders and remedies, INM, IPM and IDM.

Unit IV: Crop regulation: Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation.

Block 2: Post harvest management and marketing

Unit I: Post harvest management: Harvest indices, harvesting techniques, post-harvest handling and grading, pre-cooling, packaging and storage.

Unit II: Marketing: Important local markets, Export potential, transportation and marketing, APMC and online trading, institutional support, Crop Insurance.

Crops

Rose, jasmine, chrysanthemum, marigold, tuberose, china aster, crossandra, gaillardia, spider lily, hibiscus, nerium, barleria, celosia, gomphrena, Madar (*Calotropis gigantea*), nyctanthes (Harsingar), tabernaemontana (Chandni), lotus, water lily, michelia (Champa), gardenia, ixora and balsam.

VII. Practical

- Identification of species and varieties (1);
- Propagation and nursery management (1);
- Training and pruning techniques (1);
- Fertigation, foliar nutrition, growth regulator application (2);

- Crop protection (2);
- Pinching, disbudding, staking, harvesting techniques (1);
- Post-harvest handling, storage and cold chain (2);
- Project preparation for regionally important commercial loose flowers. crop specific guidelines for project financing (NHB guidelines) (2);
- Cost Economics (2);
- Exposure Visits to fields (2).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

After successful completion of this course, the students would have

- A thorough understanding of production and post harvest management of loose flowers.
- Develop the required skills on commercial production management

X. Suggested Reading

Arora JS. 2010. *Introductory Ornamental Horticulture*. Kalyani Publi. 6th Edition, pp. 230. Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Reprint, pp. 2065.

Bose T K, Maiti RG, Dhua RS and Das P. 1999. *Floriculture and landscaping*.

Naya Prokash, Kolkata, India.

Bose TK and Yadav LP. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.

Chadha KL and Bhattacharjee S K. 1995. *Advances in Horticulture: Ornamental Plants.* Vol.

XII, Parts 1 & 2. pp. 533, pp. 574. Malhotra Publ. House, New Delhi, India.

Chadha KL and Chaudhury B.1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India. Laurie A and Rees VH. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur.

pp.534.

Prasad S and Kumar U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur. Randhawa GS and Mukhopadhyay A. 2001. *Floriculture in India*. Allied Publ. pp 660.

Sheela VL. 2008. *Flowers for Trade*. Horticulture Science Series, vol.10, pp. 392. New India Publ. Agency, New Delhi, India.

I. Course Title : Ornamental Gardening And Landscaping

II. Course Code : FLS 505

III. Credit Hours : (2+1)

IV. Why this course ?

Ornamental gardening and landscaping is an important course which gives a thorough understanding of different types of gardens and their components. The students need to imbibe the principles of landscaping and should develop skills for planning under different situations.

V. Aim of the course

Familiarization with principles and practices of landscaping

The course is organized as follows:

No	Blocks	Units
1	Gardens and components	I. Styles and types of gardens
		II. Garden components
		III. Specialized gardens
2	Landscape planning	I. Principles and elements of landscaping
		II. Landscaping for different situations

VI. Theory

Block 1: Gardens and components

Unit I: Styles and types of gardens: Historical background of gardening, Importance and scope of ornamental gardening, styles and types of gardens, formal and informal style gardens. English, Mughal, Japanese, Persian, Spanish, Italian, French, Hindu and Buddhist gardens.

Unit II: Garden components: Garden components (living and non-living): arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, colour wheels, clock garden, bamboo groves, bonsai; Non -living components like- path, garden gate, fencing, paving and garden features like fountains, garden seating, swings, lanterns, basins, bird baths, sculptures, waterfalls, bridge, steps, ramps, Lawn -genera and species, establishment and maintenance.

Unit III: Specialized gardens: Specialised gardens such as vertical garden, roof garden, terrace garden, water garden, sunken garden, rock garden, shade garden, temple garden, sacred gardens (with emphasis on native plants), Zen garden.

Block 2: Landscape planning

Unit I: Principles and elements of landscaping: Basic drawing skills, use of drawing instruments garden symbols, steps in preparation of garden design, programmes phase, design, phase, etc.

Elements and principles of landscape design. Organization of spaces, visual aspects of plan arrangement- view, vista and axis. Principles of circulation, site analysis and landscape, water requirement, use of recycled water.

Unit II: Landscaping for different situations: Urban landscaping, Landscaping for specific situations such as residential, farm houses, institutions, corporate sector, industries, hospitals, roadsides, traffic islands, Children parks, public parks, xeriscaping, airports, railway station and tracks, river banks and dam sites and IT/ SEZ parks. Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening.

VII. Practical

- Graphic language and symbols in landscaping, study of drawing instruments, viz., 'T' square, setsquare, drawing board, etc. (1);
- Identification of various types of ornamental plants for different gardens and occasions (1);
- Preparation of land, planning, layout and planting, deviations from landscape principles (1);
- Case study (1);
- Site analysis, interpretation of map of different sites, use of GIS for selection (1);
- Enlargement from blue print. Landscape design layout and drafting on paper as per the scale (2);
- Preparation of garden models for home gardens, farm houses, industrial gardens, institutional gardens, corporate, avenue planting, practices in planning and planting of special types of gardens.(3);
- Burlapping, lawn making, planting of edges, hedges, topiary, herbaceous and shrubbery borders (2);
- Project preparation on landscaping for different situations, creation of formal and informal gardens (2);
- Visit to parks and botanical gardens (2).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- The students will be apprised of different types of gardens and have a thorough understanding of principles of landscape gardening
- Develop skills for landscaping under different situations and layout of garden components.

X. Suggested Reading

Bose TK, Chowdhury B and Sharma SP. 2011. *Tropical Garden Plants in Colour*. Hort. and Allied Publ.

Bose TK, Maiti RG, Dhua RS and Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.

Grewal HS and Singh P. 2014. *Landscape Designing and Ornamental Plants*. Kalyani Publishers, New Delhi.

Lauria A and Victor HR. 2001. *Floriculture-Fundamentals and Practices.* Agrobios Publ., Jodhpur.

Misra RL and Misra S. 2012. *Landscape Gardening*. Westville Publ. House, New Delhi, India. Nambisan KMP. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH Publ. Co.,

New Delhi, India.

Randhawa GS and Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Sabina GT and Peter KV. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency, New Delhi, India.

Singh A and Dhaduk BK. 2015. *A Colour Handbook: Landscape Gardening*. New India Publ.

Agency, New Delhi, India.

Valsalakumari PK, Rajeevan PK, Sudhadevi PK and Geetha CK. 2008. *Flowering Trees*. New India Publ. Agency, New Delhi, India.

Woodrow MG.1999. *Gardening in India*. Biotech Books, New Delhi, India.

I. Course Title : Indoor Plants and Interiorscaping

II. Course Code : FLS 506

III. Credit Hours : (1+1)

IV. Why this course ?

Indoor plants are an important component of floriculture. They not only improve the aesthetic environment of indoors but are also known to improve indoor air quality. The students in floriculture need up to date knowledge on factors affecting indoor growing, types, cultural operations and different principles of interiorscaping.

V. Aim of the course

To facilitate deeper understanding of the benefits of indoor plants, selection, designing and their management.

The course is organized as follows:

No	Blocks	Units
1	Scope, principles and operations	I. Importance and scope
		II. Classification and principles
		III. Cultural operations
2	Presentations and marketing	I. Special gardens
		II. Vertical gardens
		III. Marketing

VI. Theory

Block 1: Scope, principles and operations

Unit I: Importance and scope: Importance and scope of indoor plants and Interiorscaping, Indoor plants and Indoor air quality.

Unit II: Classification and principles: Factors affecting growth, development and flowering of Indoor plants. Classification of indoor plants based on light, temperature, humidity and pollution tolerance, Description and cultivation of various indoor plants. Principles of Interiorscaping, Role in pollution mitigation.

Unit III: Cultural operations: Containers and substrates, preparation of growing media, propagation, training, grooming, nutrition, management of disease, pests and weeds. Maintenance of plants including repotting, foliar nutrition, light exposure and plant rotation. Media standards, Nursery and Export standards for potted plants, Nursery standards.

Block 2: Presentations and marketing

Unit I: Special gardens: Special gardens including miniature gardens and plant stand. Presentations like dish, terrarium, bottle gardens, hanging baskets, window boxes and Bonsai.

Unit II: Vertical gardens: Vertical gardens- History, planting material, structures, containers, substrate, water and nutrient management, supplemental lighting.

Unit III: Marketing: Marketing channels, Business models including plant rentals.

VII. Practical

- Identification of important house plants (2);
- Media and containers (1);
- Propagation (1);
- Cultural operations, maintenance and economics of indoor plants (2);
- Models for Interiorscaping (2);
- Familiarization with different indoor gardens (2);
- Making of terrariums, bottle garden, dish garden and their economics (2);
- Making of vertical gardens and economics (2);
- Exposure visits (2).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Deep understanding and knowledge of principles affecting indoor cultivation including vertical gardens

- Develop required skills in interiorscaping
- Develop required entrepreneurial acumen

X. Suggested Reading

Barbara P. 2005. *The Complete Houseplant Survival Manual*. Storey Publ., New Adams. Randhawa GS and Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Wallach C. 1995. *Interior Decorating with Plants*. McMillan Seed Production Co. Inc., New York.

I. Course Title : Nursery Management for Ornamental Plants

II. Course Code : FLS 507

III. Credit Hours : (2+1)

IV. Why this course ?

Nursery management is very essential for production of quality planting material in ornamental plants. The course gives a thorough understanding of propagation of different ornamental plants, nursery management, standards, law and certification.

V. Aim of the course

Familiarization with principles and practices of propagation and nursery management for Ornamental plants.

The course is organized as follows:

No	Blocks	Units	
1	Nursery Industry and Propagation	I	Scenario of nursery industry and sexual propagation
		II	Asexual propagation
		III	Micropropgation
2	Nursery Management	I	Growing structures
		II	Sanitary and phytosanitary issues
		III	Standards

VI. Theory

Block 1: Nursery Industry and Propagation

Unit I: Scenario of nursery industry and sexual propagation: Importance and present scenario and status of nursery industry in India and in the world, life cycles in plants, Propagation methods, Factors influencing seed germination of flower crops, dormancy, seed quality, packing, storage, certification, testing. Hormonal regulation of germination and seedling growth.

Unit II: Asexual propagation: Methods of asexual propagation, rooting of soft and hard wood cutting under mist. Role of Plant growth regulators. Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principles and methods, budding and grafting – selection of elite mother plants. Stock, scion and inter stock, relationship – Incompatibility.

Unit III: Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in flower crops. Techniques – *in-vitro* clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture. Hardening, packing and transport of micro-propagules.

Block 2: Nursery Management

Unit I: Growing structures: Growing structures like mist chambers, tunnels, lath house, net house, growing media types, soil less culture and containers. Automation in nursery management.

Unit II: Sanitary and phyto-sanitary issues: Nursery – types, components, planning and layout. Nursery management practices for healthy propagule production. Nursery Act, PPV&FR act and Quarantine system in India. Important quarantine pests and diseases, sanitary and phyto-sanitary issues threats to nursery Industry.

Unit III: Standards: Nursery standards, Hi-tech nurseries, garden centers.

VII. Practical

- Anatomical studies in rooting of cutting and graft union (2);
- Identification and production of plug plants, seedlings and saplings (2);
- Preparation of growing media and use of PGRs (2);
- Practice of propagation through specialized structures cuttings, layering, budding and grafting (2);
- Case studies (2);

- Micropropagation of ornamental crops and hardening (3);
- Visit to tissue culture labs and nurseries (2);
- Economics (1).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

After successful completion of this course,

- The students will develop thorough understanding of nursery management in flower crops.
- Empower the students with the knowledge to start an enterprise
- Hone adequate skill in propagation and management

X. Suggested Reading

Adriance GW and Brison FR. 2000. *Propagation of Horticultural Plants*. Biotech Books, New Delhi, India.

Bose TK, Mitra SK and Sadhu M K. 1991. *Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash, Kolkata, India.

Chadha KL, Ravindran PL and Leela Sahijram. 2000. *Biotechnology in Horticulture and Plantation Crops*. Malhotra Publ. House, New Delhi, India.

Davies Fred T Jr., Geneve RL, Wilson SB, Hartmann HT and Kester DL. 2018. *Hartmann and Kester's Plant Propagation: Principles and Practices.*

Pearson Publ. 9th Edition.

Peter KV. 2008. *Basics of Horticulture*. New India Publ. Agency, New Delhi, India.

Rajan S and Baby LM. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency, New Delhi, India. pp. 251.

Singh SP. 1989. *Mist Propagation*. Metropolitan Book Co., New Delhi, India.

I. Course Title : Turfgrass Management

II. Course Code : FLS 508

III. Credit Hours : (2+1)

IV. Why this course ?

Turf grass management deals with establishment and maintenance of different turf grasses for aesthetic, recreational and sports purposes. The course deals with basic types, requirement of turf grasses, management and development of turf for different purposes.

V. Aim of the course

To understand the science, principles and management of turf grasses. The course is organized as follows:

No	Blocks	Units
1	Turf Industry and turf management	I Prospects and basic requirement
		II Types of turf grasses
		III Operations and management
2	Turf for different ground	I Making of different sports arenas
		II Automation in turf management

VI. Theory

Block 1: Turf industry and turf grasses

Unit I: Prospects and basic requirement: History, present status and prospects of turf industry; basic requirements, site selection and evaluation, concepts of quality of soil pertaining to turf grass establishment, criteria for evaluation of turf quality.

Unit II: Types of turf grasses: Types, species, varieties, important breeders, grasses for different locations and conditions and their compatible groupings as per climatic conditions; Turfing for roof gardens.

Unit III: Operations and management: Preparatory operations; Turf establishment methods such as seeding, sprigging/ dibbling, plugging, sodding/ turfing, turf plastering, instant turfing (portable), hydro- seeding, synthetic turfing. Turf management – Irrigation, drainage, nutrition, special practices like aerating, rolling, coring, dethatching, verticutting, soil top dressing, use of plant growth regulators and micronutrients, Turf mowing – mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs, standards for turf, use of recycled water, etc.

Block 2: Turf for different grounds

Unit I: Making of different sports arenas: Establishment and maintenance of turfs for playgrounds, viz., golf, football, hockey, cricket, tennis, rugby, residential and public parks, turfing of Govt. and Corporate office gardens, event specific preparation, turf colourants.

Unit II: Automation: Exposure to different tools, gadgets, machinery used in turf industry.

VII. Practical

- Identification of turf grasses and turf machinery (1);
- Soil preparation, turf establishment methods, provision of drainage (2);
- Layout of macro and micro irrigation systems (1);
- Water and nutrient management (2);
- Special practices – mowing, raking, rolling, soil top dressing, weed management (2);
- Biotic and abiotic stress management (2);
- Project preparation for turf establishment (2);
- Visit to parks, model cricket grounds and golf courses, airports, corporates, Govt. organizations (2);
- Rejuvenation of lawns (1);
- Turf economics (1).

VIII. Teaching Methods/ Activities

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

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

- Deep understanding and knowledge of different types of grasses and their management
- Developing skills for turfing of different arenas
- Develop required entrepreneurial acumen

X. Suggested Reading

Aldous D.1999. *International Turf Management Handbook.* CRC Press. pp.368.

Beard JB. 1972. *Turf Grass Science and Culture*. Pearson. 1st edition, pp. 672.

Chawla SL, Patil S, Patel MA, Patel RB and Patel RM. 2013. *Turf grass Management*. Publised by NAU, Navsari.

Emmons R. 2007. *Turf grass Science and Management*. Cengage Learning Publ. 4th edition, pp. 592.

Nick-Christians. 2011. *Fundamentals of Turf grass Management*. Wiley; 4th Edition, pp. 424. Turgeon AJ. 1980. *Turf grass Management*. Reston Publ. Inc.

I. Course Title : Value Addition in Floriculture

II. Course Code : FLS 509

III. Credit Hours : (2+1)

IV. Why this course ?

Value addition is done to increase the economic value of any floriculture commodity. Students need to develop thorough understanding of scope, scenario and different methods of value addition so that they can improve the income of the stakeholders by value addition.

V. Aim of the course

To understand the avenues for value addition in floriculture The course is organized as follows:

No	Blocks	Units
1	Value added products	I Scope and scenario
		II Value addition of loose flowers
		III Floral Arrangements
		IV Dry flowers
2	Extraction of value added products	I Essential oils
		II Pigments and nutraceuticals

VI. Theory

Block 1: Value added products

Unit I: Scope and scenario: Scope and prospects of value addition, National and global scenario, production and exports. Types of value added products, techniques of value addition including tinting.

Unit II: Value addition in loose flowers: Value addition in loose flowers and product development- Gulkhand, floral tea, rose oil, rose water, Pankhuri, floral dyes, rose sherbet, floral ice creams, sweets, etc.

Unit III: Floral Arrangements: Selection of containers and accessories for floral products and decorations. Flower arrangement, styles, ikebana schools.

(*ikenobo, ohara, sogetsu,* etc.), Ikebana- moribana, nagiere, contemporary style.

Unit IV: Dry flowers: Dry flowers– Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; tips for collecting dry flower making, selection of stages for picking of flowers for drying, Techniques in dry flower making – Drying, glycerising, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; petal embedded handmade papers, Packaging and storage. Post drying management including moisture, pests and molds.

Block 2: Extraction of value added products

Unit I: Essential oils: Essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packing and storage, Aromatherapy.

Unit II: Pigments and nutraceuticals: Types of pigments, carotenoids, anthocyanins, chlorophyll, betalains; Significance of natural pigments as nutraceuticals, Extraction methods and applications in food, pharmaceutical and poultry industries.

Unit III: Dying: Synthetic and Natural dyes, dying techniques, colour retention,

VII. Practical

- Practices in preparation of different type of flower arrangements including bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers (4);

- Techniques in flower arrangement and floral decoration (2);
- Identification of plants for dry flower making (2);
- Practices in dry flower making; Preparation of dry flower baskets, bouquets, pot- pourri, wall hangings, button holes, greeting cards, wreaths, etc. (2);
- Essential oil extraction units (1);
- Extraction of pigments (2);
- Visit to dry flower units (2);
- Economics of value added products (1).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- Understand and prepare different value added products from flowers
- Develop entrepreneurial acumen
- Imbibe the skills for making various value added products

X. Suggested Reading

Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Reprint, pp. 2065.

Chadha KL and Bhattacharjee SK. 1995. *Advances in Horticulture: Ornamental Plants.* Vol.

XII, Parts 1 & 2. pp.533 and pp.574. Malhotra Publ. House, New Delhi, India.

Lauria A and Victor HR. 2001. *Floriculture-Fundamentals and Practices.*Agrobios Publ., Jodhpur.

Nowak J and Rudnicki RM. 1990. *Postharvest handling and storage of cut flowers, florist greens, and potted plants*. Timber Press, USA. pp. 210.

Prasad S and Kumar U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur.

Reddy S, Janakiram T, Balaji T, Kulkarni S and Misra RL. 2007. *Hi- Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi, India.

I. Course Title : Protected Cultivation of Flower Crops

II. Course Code : FLS 510

III. Credit Hours : (2+1)

IV. Why this course ?

Protected cultivation is more rewarding in production of high value cut flowers. With appropriate structures and plant environment control measures, the constraints of environment prevalent in the region can be overcome allowing almost year- round cultivation. The students need a thorough understanding of principles, types, designs, crops for different environments and management of environment in protected cultivation.

V. Aim of the course

Understanding the principles, theoretical aspects and developing skills in protected cultivation of flower crops.

The course is organized as follows

No	Blocks	Units
1.	Principles and types structures	I Prospects and types of protected II Principles and designs
2.	Growing Environment	I Control of II. Crop management and crop regulation III. Automation and standards

VIII. Theory

Block 1: Principles and types

Unit I: Prospects and types of protected structures: Prospects of protected floriculture in India; Types of protected structures – Glasshouse/ polyhouse, shadenet houses, mist chambers, lath houses, orchidarium, fernery, rain shelters, etc.

Unit II: Principles and design: Principles of designing and erection of protected structures; Low cost/ Medium cost/ High cost structures; Location specific designs; Structural components; Suitable flower and foliage plants for protected cultivation.

Block 2: Growing environment

Unit I: Control of environment: Microclimate management and manipulation of temperature, light, humidity, air and CO_2; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation, water harvesting.

Unit II: Intercultural operations and crop regulation: Containers and substrates, media, soil decontamination, layout of drip and fertigation system, water and nutrient management, IPM and IDM, Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.

Unit III: Automation and standards: Automation in greenhouses, sensors, solar greenhouses and retractable greenhouses, GAP/ Flower labels, Export standards, EXIM policy, APEDA regulations for export, Non-tariff barriers.

Crops

Rose, Chrysanthemum, Carnation, Gerbera, Orchids, Anthuriums, Lilium, Limonium, Lisianthus, heliconia, Cala lily, Alstromeria, etc.

IX. Practical

- Study of various protected structures (1);
- Design, layout and erection of different types of structures (2);
- Practices in preparatory operations, growing media, soil decontamination techniques (2);
- Microclimate management (2);
- Practices in drip and fertigation techniques, special horticultural practices (2);
- Determination of harvest indices and harvesting methods (1);
- Postharvest handling, packing methods (1);
- Economics of cultivation, Project preparation (2);
- Project Financing guidelines (1);
- Visit to commercial greenhouses (2).

X. Teaching Methods/ Activities

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

XI. Learning outcome

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

- Knowledge on types, design and principles of protected structures
- Thorough understanding of principles of microclimate management and crop management.
- Develop the required skills for designing a greenhouse

- Acquire skills on microclimate management, production management

XII. Suggested Reading

Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Reprint, pp. 2065.

Bose TK, Maiti RG, Dhua RS and Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.

Bose TK and Yadav LP. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.

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XII, Parts 1 & 2. pp.533 and pp.574. Malhotra Publ. House, New Delhi, India.

Lauria A and Victor HR. 2001. *Floriculture-Fundamentals and Practices.*Agrobios Publ., Jodhpur.

Nelson PV. 2011. *Green House Operation and Management*. Pearson Publ. 7th edition, pp. 624.

Prasad S and Kumar U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur. Randhawa GS and Mukhopadhyay A. 1986. *Floriculture in India*. Allied Publ.

Reddy S, Janakiram T, Balaji T, Kulkarni S and Misra RL. 2007. *Hi- Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi, India

I. Course Title : CAD for Landscaping

II. Course Code : FLS 511

III. Credit Hours : (1+2)

IV. Why this course ?

CAD is widely used in landscaping planning and design. The students need to develop in depth knowledge of CAD software so that they can modify raw data into plans, drawing and models for landscape planning.

V. Aim of the course

To impart basic knowledge about the Computer Aided Designing (CAD) of landscape. The course is organized as follows

No	Blocks	Units
1	CAD	I CAD basics and applications
		II 2D drawing
2	ARCHICAD	I 3D drawing
		II Dimensioning and visualization

VI. Theory

Block 1: CAD

Unit II: CAD basics and applications: Principles of integrating the architecture and landscaping, Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing.

Unit II: 2D drawing: 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects. Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking, Script

making, Using productivity tools, e-transmit file, making sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout.

Block 2: ARCHICAD

Unit I: 3D drawing: 3D drawing methods, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD.

Unit II: Dimensioning and visualization: ARCHICAD organization tools, Dimensioning and detailing of designs, Landscape designing softwares and CD ROM for ornamental plant material (TRES, HIMFLORA, CAPSSA, etc), Attribute settings of components, Visualization tools for landscape preview, Data management, plotting and accessories for designing, Inserting picture using photoshop, Making sample drawing for outdoor and indoor gardens.

VII. Practical

- Practices in point picking methods, Using tool bars and icons, Using modifying tools and modifying comments (4);
- Isometric drawings, Using productivity tools (2);
- Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden (4);
- Using tools and info-box for 3D drawing, Creation of garden components with ARCHICAD (4);
- Organization, dimensioning, detailing and visualization tools with ARCHICAD (4);
- Using Photoshop package for 3D picture insertion (2);
- Drawing designs with ARCHICAD for home garden, interior garden designing, IT parks, Corporates, Theme parks and Ecotourism spots (6);

- Exposure visits (4).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

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

- The students will be able to use CAD and ARCHICAD for landscape planning and designing.
- Develop the adequate skills to create 3 D model to showcase interaction of different factors in landscape gardening.
- Develop the entrepreneurial acumen

X. Suggested Reading

Christine, Wein-Ping Yu. 1987. *Computer-aided Design: Application to Conceptual Thinking in Landscape Architecture*. amazon.com.

Misra RL and Misra S. 2012. *Landscape Gardening*. Westville Publ. House, New Delhi, India.

I. **Course Title : Seed Production in Flower Crops**

II. **Course Code : FLS: 512**

III. **Credit Hours : (1+1)**

IV. **Why this course ?**

Seed production of flowers is a highly remunerative enterprise. The students need to have knowledge of seed industry, seed production methods and seed certification. This course provides hands on training on seed production of important flower crops.

V. Aim of the course

To impart basic knowledge about the importance of seed production in important flower crops.

The course is organized as follows

No	Blocks	Units	
1	Seed Industry	I	Scenario of Seed industry
2	Hybrid Seed Production	I	Seed Production methods
		II	Population improvement
		III	F1 Hybrid production
3	Regulations	I	Seed certification and standards

VI. Theory

Block 1: Seed Industry

Unit I: Scenario of Seed Industry: Scope, scenario and importance of seed

production in flower crops. Constraints in flower seed production. Marketing and economics of flower seeds.

Block 2: Hybrid Seed Production

Unit I: Seed production-Methods: Methods of seed production, agrotechniques for production of nucleus, breeder and certified seeds. Harvesting, seed processing, seed priming, seed chain, packaging and storage.

Unit II: Population improvement: Mass selection, progeny selection.Use of incompatibility and male sterility, maintenance of variety and seed production in flower crops.

Unit III: F1 hybrids: F1 hybrid seed production advantages, steps involved in hybrid seed production, pollination behaviour and isolation, pollination management methods in production of F1/ hybrids in different flower crops.

Block 3: Regulations

Unit I: Seed certification and standards: Seed certification, Seed standards, seed act, plant breeders rights and farmers' rights, Bio safety, handling of transgenic seed crops, importing of seeds and OGL, trade barriers in seed business, sanitary and phytosanitaty issues, custom clearance and quarantine.

Crops

Marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum, poppy, corn flower, rice flower.

VII. Practical

- Seed production of open pollinated varieties (2);
- Seed production of cross pollinated varieties (2);
- Steps involved in hybrid seed production (2);
- Hybrid seed production in different flower crops like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum, etc. (6);
- Visit to seed industry (3);
- Visit to quarantine facility (1).

VIII. Teaching Methods/ Activities

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

IX. Learning outcome

After successful completion of this course,

- The students will get a thorough knowledge on seed industry, principles and methods of seed production in flower crops.
- Students will get awareness on seed standards, certification and law in flower crops.

X. Suggested Reading

Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI.

Pointer Publ.

Reprint, pp. 2065.

Bose TK, Yadav LP, Pal P, Parthasarathy VA and Das,P. 2003. *Commercial Flowers*. Vol. I &

II. Naya Udyog, Kolkata, India.

Davies, Fred T Jr., Geneve RL, Wilson SB, Hartmann HT. Kester DL. 2018. *Hartmann and Kester's Plant Propagation: Principles and Practices.* Pearson Publ.9th Edition.

Larson RA and Armitage AM. 1992. *Introduction of Floriculture*. International Book Distributing Co., Lucknow, India.

Horticultural Sciences

– Plantation, Spices, Medicinal and Aromatic Crops

Plantation Crops are high value commercial crops of greater economic importance and play a vital role in our national economy. Crops like tea, coffee, rubber, coconut, arecanut, cocoa, oil palm, cashew, etc. occupy less than two percent of the total cultivated area but have a stake of 16% of the total export earnings of all commodities or 75% of total earnings from the export of agricultural produce. Plantation industry provides direct as well as indirect employment to many millions of people and also supports other by-product industries and many rural industries. Therefore, the country has considered horticulture and plantation sector as the growth engine of agricultural economy.

Spices are important group of horticultural crops providing livelihood to millions of peoples in the country. They have tremendous importance in the way we live, as ingredients in foods, alcoholic beverages, medicine, perfumery, cosmetics, pharmaceuticals, coloring and also as garden plants. Out of the total 109 spices listed by the International Organization for Standards (ISO), 63 are grown in India. The trade in spices is one of the oldest and currently the most important form of commerce. The tropical humid regions of India grows major spices like black pepper, cardamom, ginger, turmeric, nutmeg, cinnamon, clove, etc. and the arid and semi arid parts of India are known as the seed spice bowl.

The medicinal and aromatic plant sector plays a significant role in the subsistence economy of the people. The domestic as well as export market of MAP is ever increasing. The annual turn over of the major Indian systems of medicine ie, Ayurveda, Unani, and Sidha is estimated to be more than half a million dollars. The MAP sector is also an integral part of natural resource management contributing to economic growth, environmental protection and trade.

In the present syllabus, courses have been organized to cover the current requirements of the plantation, spice and MAP sector to increase the capability of horticulture graduates. Either new courses have been formulated or existing courses upgraded to include latest developments in various sectors. In the masters programme new courses ie, systematics, growth and development, biochemistry and biodiversity conservation of PSMA crops have been included. In most of the PSMA crops quality of the produce is of paramount importance and hence a thorough understanding of the systematics, growth and developmental physiology and biochemistry is essential. To ensure sustainability aspects, biodiversity management are also added. Both national as well as global perspectives are taken care of in deciding the course content, especially in the case of doctoral programme. Tools of biotechnology have been extensively utilized in the improvement of PSMA crops and the course to this effect has been included. As the climate changes are happening globally and being crops which are greatly influenced by the change if climate, a course on abiotic stress management is included. As most of the PSMA crops are export oriented, separate courses
on organic production and export are also included. All courses are designed in line with the national initiatives as well as the global scenario.

Course Title with Credit Load

M.Sc. (Hort.) in Plantation, Spices, Medicinal and Aromatic Crops

Course Code	Course Title	Credit Hours
	Major Courses (20 Credits)	
PSM 501*	Production of Plantation Crops	2+1
PSM 502*	Production of Spice Crops	2+1
PSM 503*	Production of Medicinal and Aromatic Crops	2+1
PSM 504*	Breeding of Plantation and Spice Crops	2+1
PSM 505*	Breeding of Medicinal and Aromatic Crops	1+1
PSM 506	Systematics of Plantation and Spice Crops	1+1
PSM 507	Systematics of Medicinal and Aromatic Crops	1+1
PSM 508	Underexploited Plantation, Spice, Medicinal and Aromatic Plants	2+0
PSM 509	Growth and Development of Plantation, Spice, Medicinal	2+1
PSMA 510	Biochemistry of Plantation, Spice, Medicinal and Aromatic crops	2+1
PSMA 511	Biodiversity and Conservation of Plantation, Spice, Medicinal and Aromatic Crops	2+1
	Minor Courses	08
	Supporting Courses	06
	Common compulsory courses	05
PSMA 591	Seminar	0+1
PSMA 599	Research	0+30
	Total	70

*Compulsory among major courses

Course Contents

M.Sc. (Hort.) in Plantation, Spices, Medicinal and Aromatic Crops

I. Course Title : Production of Plantation Crops

II. Course Code : PSM 501

III. Credit Hours : (2+1)

IV. Why this course ?

Plantation crops play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers. This course will impart theoretical as well as hands-on experience to the learner on scientific production technology of various plantation crops in Indian perspectives. It will provide comprehensive knowledge in this regard.

V. Aim of the course

The course is designed to provide both basic and applied knowledge on various aspects of production technology of plantation crops grown in India.

The course is organized as follows:

No	Blocks	Units	
1	Importance of Plantation Crops	I	Role of plantation crops
		II	Export potential
		III	Promotional programmes
2	Production Technology	I	Varietal wealth
		II	Propagation and nursery management
		III	Agro techniques
3	Harvest and Post-harvest	I	Maturity indices and harvest management
		II	Post harvest management

VI. Theory

Block 1: Importance of Plantation Crops

Unit 1: Role of plantation crops: Role of plantation crops in national economy, area-production statistics at national and international level, classification, clean development mechanism and carbon sequestration potential of plantation crops.

Unit 2: Export potential: Export potential, problems and prospects and IPR issues in plantation crops.

Unit 3: Promotional programmes: Role of commodity boards and directorates in the development programmes of plantation crops.

Block 2: Production Technology

Unit 1: Varietal wealth: Botany, taxonomy, species, cultivars and improved varieties in plantation crops.

Unit 2: Propagation and nursery management: Plant multiplication including *in-vitro* multiplication, nursery techniques and nursery management in plantation crops.

Unit 3: Agro techniques: Systems of cultivation, cropping systems, multitier cropping, climate and soil requirements, systems of planting, high density planting, nutritional requirements, water requirements, fertigation, moisture conservation, role of growth regulators, macro and micro nutrients, nutrient deficiency symptoms, physiological disorders, shade regulation, weed management, training and pruning, crop regulation, plant protection, management of drought, precision farming.

Block 3: Harvest and Post harvest management

Unit 1: Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons and mechanized harvesting in plantation crops.

Unit 2: Post harvest management: Post harvest handling including primary processing, grading, packaging, storage and benefit cost analysis of plantation crops.

Crops

Coconut, Arecanut, Oilpalm, Cashew, Coffee, Tea, Cocoa, Rubber, Palmyrah, Betel vine

VII. Practical

- Description of botanical and varietal features;
- Selection of mother palms and seedlings;
- Nursery techniques;
- Soil and water conservation measures;
- Nutrient deficiency symptoms;

- Manuring practices;
- Pruning and training methods;
- Maturity standards;
- Harvesting;
- Project preparation for establishing plantations;
- GAP in plantation crops;
- Exposure visits to commercial plantations, research institutes.

VIII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Demonstration
- Exposure visits

IX. Learning outcome

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

- Develop the technical skill in commercial cultivation of plantation crops
- Be able to start plantation crop-based enterprises

X. Suggested Reading

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

Anonymous. 1985. *Rubber and its Cultivation*. The Rubber Board of India.

Chopra VL and Peter KV. 2005. *Handbook of Industrial Crops*. Panima.

Choudappa P, Anitha K, Rajesh MK and Ramesh SV. 2017. *Biotechnology of Plantation Crops*.

Daya Publishing House, New Delhi

Choudappa P, Niral V, Jerard BA and Samsudeen K. 2017. *Coconut*. Daya Publishing House, New Delhi.

e-manual on Advances in Cashew Production Technology. ICAR –Directorate of Cashew Research, Puttur –574 202, DK, Karnataka.

Harler CR. 1963. *The Culture and Marketing of Tea*. Oxford Univ. Press.

Joshi P. 2018. *Text Book on fruit and plantation crops*. Narendra Publishing House, New Delhi Kurian A and Peter KV. 2007. *Commercial Crops Technology*. New India Publ. Agency.

Nair MK, Bhaskara Rao EVV, Nambia KKN and Nambiar MC. 1979. *Cashew*. CPCRI, Kasaragod.

Panda H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.

Panda H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition).

Asia Pacific Business Press Inc.

Peter KV. 2002. *Plantation Crops.* National Book Trust.

Pillay PNR. 1980. *Handbook of natural rbber production in India*. Rubber Research Institute, Kottayam. pp.668.

Pradeepkumar T, Suma B, Jyothibhaskar and Satheesan KN. 2007. *Management of Horticultural Crops.* Parts I, II. New India Publ. Agency.

Ramachandra *et al.* 2018. *Breeding of Spices and Plantation crops*. Narendra Publishing House, New Delhi.

Ranganathan V. 1979. *Hand Book of Tea Cultivation.* UPASI, Tea Res. Stn. Cinchona.

Sera T, Soccol CR, Pandey A, Roussos S *Coffee Biotechnology and Quality*. Springer, Dordrecht.

Sethuraj MR and Mathew NT. 1992. *Natural Rubber: Biology, Cultivation and*

Technology (Developments in Crop Science). Elsevier Science.

Sharangi AB and Datta S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.

Sharangi AB and Acharya SK. 2008. *Quality management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2.

Srivastava HC, Vatsaya and Menon, KKG. 1986. *Plantation Crops – Opportunities and Constraints.* Oxford and IBH.

Thampan PK. 1981. *Hand Book of Coconut Palm*. Oxford and IBH.

I. **Course Title : Production of Spice Crops**

II. **Course Code : PSM 502**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Spice crops play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers. This course will impart theoretical as well as hands-on experience to the learner on scientific production technology of various spice crops in Indian perspectives. It will provide comprehensive knowledge in this regard.

V. Aim of the course

The course is designed to provide both basic and applied knowledge on various aspects of production technology of spice crops grown in India.

The course is organized as follows:

No	Blocks	Units	
1	Importance of Spice Crops	I	Role of spice crops

		II Classification of spice crops
2	Production Technology	I Varietal wealth

No	Blocks	Units
		II Propagation and nursery management
		III Agro techniques
3	Harvest and Post harvest	I Maturity indices and harvest management
		II Post harvest management

VI. Theory

Block 1: Importance of spice crops

Unit 1: Role of Spice crops: Introduction, importance of spice crops, pharmaceutical significance, historical accent, present status – national and international, future prospects, role of Spices board and other development agencies.

Unit 2: Classification of spice crops: Major spices, minor spices, seed spices, tree spices, herbal spices.

Block 2: Production Technology

Unit 1: Varietal wealth: Botany and taxonomy, species, cultivars, commercial varieties/ hybrids in spice crops.

Unit 2: Propagation and nursery management: Seed, vegetative and micro-propagation methods, nursery techniques and nursery management practices.

Unit 3: Agro techniques: Climatic and soil requirements, site selection, layout, sowing/ planting times and methods, seed rate and seed treatment,

nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, plant protection, precision farming, physiological disorders, protected cultivation.

Block 3: Harvest and Post harvest management

Unit 1: Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons, mechanized harvesting.

Unit 2: Post harvest management: Post harvest management including primary processing, grading, packaging and storage, GMP in major spice crops.

Crops

Black pepper, small and large Cardamom, Turmeric, Ginger, Garlic, Coriander, Fenugreek, Cumin, Fennel, Ajwain, Saffron, Vanilla, Nutmeg, Clove, Cinnamon, Allspice, Tamarind, Garcinia

VII. Practical

- Identification of seeds and plants;
- Botanical description of plant;
- Varietal features;
- Planting material production;
- Field layout and method of planting;
- Cultural practices;
- Harvest maturity, harvesting;
- Drying, storage, packaging;
- Primary processing;

- GAP in spice crops;
- GMP in spice crops;
- Short term experiments on spice crops;
- Exposure visits to spice farms, research institutes.

VIII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Demonstration
- Exposure visits

IX. Learning outcome

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

- Develop the technical skill in commercial cultivation of spice crops
- Be able to start spice-based enterprises

X. Suggested Reading

Agarwal S, Sastry EVD and Sharma RK. 2001. *Seed Spices: Production, Quality, Export.* Pointer Publ.

Arya PS. 2003. *Spice Crops of India.* Kalyani.

Bose TK, Mitra SK, Farooqi SK and Sadhu MK. Eds. 1999. *Tropical Horticulture.* Vol.I. Naya Prokash.

Chadha KL and Rethinam P. Eds. 1993. *Advances in Horticulture.* Vols. IX-X. *Plantation Crops and Spices.* Malhotra Publ. House.

Gupta S. Ed. *Hand Book of Spices and Packaging with Formulae.* Engineers India Research Institute, New Delhi.

Kumar NA, Khader P, Rangaswami and Irulappan I. 2000. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants.* Oxford and IBH.

Nybe EV, Miniraj N and Peter KV. 2007. *Spices.* New India Publ. Agency.

Parthasarthy VA, Kandiannan V and Srinivasan V. 2008. *Organic Spices.* New India Publ.

Agency.

Peter KV. 2001. *Hand Book of Herbs and Spices.* Vols. I-III. Woodhead Publ. Co. UK and CRC USA.

Ponnuswami V *et al.* 2018. *Medicinal Herbs and Herbal Cure*. Narendra Publishing House, New Delhi.

Pruthi JS. Ed. 1998. *Spices and Condiments.* National Book Trust.

Pruthi JS. 2001. *Minor Spices and Condiments- Crop Management and Post Harvest Technology*.

ICAR.

Purseglove JW, Brown EG, Green CL and Robbins SRJ. Eds. 1981. *Spices.* Vols. I, II. Longman. Ramachandra *et al.* 2018. *Breeding of Spices and Plantation crops*. Narendra Publishing House,

New Delhi.

Ravindran PN. 2000. *Black pepper*, *Piper nigrum*. CRC press. Ravindran PN. 2002. *Cardamom, the genus Elettaria*. CRC press Ravindran PN. 2003. *Cinnamon and cassia.* CRC press Ravindran PN. 2004. *Ginger, the genus Zingiber*. CRC press Ravindran PN. 2007. *Turmeric, the genus curcuma*. CRC press Ravindran PN. 2017. *The Encyclopedia of Herbs and Spices*. CABI

Shanmugavelu KG, Kumar N and Peter KV. 2002. *Production Technology of Spices and Plantation Crops.* Agrobios.

Sharangi AB, Datta S and Deb P. 2018. Spices "*Agrotechniques for quality produce*". Apple Acadamic Press (Tylor and Francis Groups), New Jersey, USA.

Sharangi AB. 2018. Indian Spices "*The legacy, production and processing of India's treasured export."* Springer International publishing AG, Part of Springer Nature 2018, Cham, Switzerland.

Future directions. SPRINGER; ISBN: 978-81-322-2261-3.

Sharangi AB and Acharya SK. 2008. *Quality Management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2.

Thamburaj S and Singh N. Eds. 2004. *Vegetables, Tuber Crops and Spices,* ICAR.

Tiwari RS and Agarwal A. 2004. *Production Technology of Spices*. International Book Distr.

Co.

I. **Course Title : Production of Medicinal and Aromatic Crops**

II. **Course Code : PSM 503**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Medicinal and aromatic crops play an important role in the national economy of India. These crops also provide health security to all. This course will impart theoretical as well as hands-on experience to the learner on scientific production technology of various medicinal and aromatic crops in Indian perspectives. It will provide comprehensive knowledge in this regard.

V. Aim of the course

To impart comprehensive knowledge on the production technology of important medicinal and aromatic crops

The course is organized as follows:

No	Blocks	Units	
1	Importance of Medicinal and	I	Classification of medicinal Aromatic

	Crops	and aromatic crops
		II Medicinal plant based industry
		III Aromatic plant based industry
2	Production technology	I Varietal wealth
		II Propagation and nursery management
		III Agro techniques
3	Harvest and Post harvest	I Maturity indices and harvest management
		II Post harvest management

Theory

Block 1: Importance of Medicinal and Aromatic Crops

Unit 1: Classification of medicinal and aromatic crops: Importance of medicinal plants, Importance of aromatic plants, Role in national economy, utility sectors of medicinal and aromatic crops, classification of medicinal and aromatic crops, role of institutions, Medicinal Plant Board and NGO's in research and development of medicinal and aromatic crops.

Unit 2: Medicinal and plant based industry: Indian system of medicine, traditional systems of medicine, tribal medicine, medicinal industry, source of medicinal plants, area, production, export and import of major crops, problems, prospects and challenges, IPR issues.

Unit 3: Aromatic plant based industry: Essential oils, classification, physical and chemical properties and storage of essential oils. Indian perfumery industry,area, production, export and import status of major aromatic

crops, history and advancements, problems, prospects and challenges, IPR issues.

Block 2: Production technology of medicinal and aromatic crops

Unit 1: Varietal wealth: Botany and taxonomy, species, cultivars, commercial varieties/ hybrids in medicinal and aromatic crops.

Unit 2: Propagation and nursery management: Seed, vegetative and micro-propagation methods, nursery techniques and nursery management practices.

Unit 3: Agro techniques: Climatic and soil requirements, site selection, layout, sowing/ planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, plant protection.

Block 3: Harvest and Post harvest management

Unit 1: Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons in medicinal and aromatic crops.

Unit 2: Post harvest management: Post harvest management including primary processing, extraction, grading, packaging and storage, GMP in medicinal and aromatic crops.

Crops

A. Medicinal crops: Senna, periwinkle, medicinal coleus, aswagandha, glory lily, sarpagandha, *Dioscorea* sp., *Aloe vera*, *Andrographis paniculata, Digitalis,* medicinal solanum, isabgol, opium poppy, safedmusli, *Stevia rebaudiana, Mucuna pruriens, Piper longum, Plumbago zeylanica*

B. Aromatic crops: Palmarosa, lemongrass, citronella, vetiver, mentha, patchouli, sweet flag, jasmine, geranium, artemisia, lavender, *Ocimum* sp., eucalyptus, sandal

VI. Practical

- Description of botanical and varietal features;
- Nursery techniques;

- Lay out and planting;
- Manuring practices;
- Maturity standards;
- Harvesting;
- Primary processing;
- Extraction of oils;
- Herbarium preparation;
- Project preparation for establishing herbal gardens;
- GAP in medicinal and aromatic crops;
- GMP in medicinal and aromatic crops;
- Exposure visits to institutes, herbal gardens and industries.

VII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Demonstration
- Exposure visits

VIII. Learning outcome

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

- Develop the technical skill in commercial cultivation of medicinal and aromatic crops
- Be able to start medicinal and aromatic crop-based enterprises

IX. Suggested Reading

Atal CK and Kapur BM. 1982. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.

Barche S. 2016. *Production technology of spices, aromatic, medicinal and plantation crops*. New India Publishing Agency, New Delhi.

Das K. 2013. *Essential oils and their applications*. New India Publishing Agency, New Delhi Farooqi AA and Sriram AH. 2000. *Cultivation Practices for Medicinal and Aromatic Crops*. Orient Longman Publ.

Farooqi AA, Khan MM and Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops.* Natural Remedies Pvt. Ltd.

Gupta RK. 2010. *Medicinal and Aromatic plants*. CBS publications.

Hota D. 2007. *Bio Active Medicinal Plants*. Gene Tech Books. Jain SK. 2000. *Medicinal Plants.* National Book Trust.

Khan IA and Khanum A. 2001. *Role of Biotechnology in Medicinal and Aromatic Plants*. Vol. IX. Vikaaz Publ.

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Panda H. 2002. *Medicinal Plants Cultivation and their Uses.* Asia Pacific

Business Press. Panda H. 2005. *Aromatic Plants Cultivation, Processing and Uses.* Asia Pacific Business Press. Ponnuswami *et al.* 2018. *Medicinal Herbs and Herbal Cure*. Narendra Publishing House, New Delhi.

Prajapati SS, Paero H, Sharma AK and Kumar T. 2006. *A Hand book of Medicinal Plants*. Agro Bios.

Ramawat KG and Merillon JM. 2003. *BioTechnology – Secondary Metabolites*. Oxford and IBH.

Shankar SJ. 2018. *Comprehensive post harvest technology of flowers, medicinal and aromatic plants*. Narendra Publishing House, New Delhi.

Skaria PB, Samuel M, Gracy Mathew, Ancy Joseph, Ragina Joseph. 2007. *Aromatic Plants*. New India Publ. Agency.

I. Course Title : Breeding of Plantation and Spice Crops

II. Course Code : PSM 504

III. Credit Hours : (2+1)

IV. Why this course ?

Plantation and spice crops play an important role in the national economy of India. For maximizing the production, productivity and quality of plantation and spice crops, fundamental knowledge on breeding methods of the major crops is essential. This course will impart theoretical as well as hands-on experience to the learner on reproductive biology, breeding methods and breeding achievements in various plantation and spice crops

V. Aim of the course

To impart comprehensive knowledge on the principles and practices in the breeding of important plantation and spice crops

No	Blocks	Units
1	Genetic diversity	I Species and cultivar diversity
		II Germplasm evaluation
2	Crop improvement	I Breeding objectives
		II Breeding methods
3	Breeding achievements and	I Breeding achievements future thrusts
		II Future thrusts

VI. Theory

Block 1: Genetic diversity

Unit I: Species and cultivar diversity: Floral and reproductive biology, cytogenetics, male sterility, incompatibility, wild and cultivated species, popular cultivars.

Unit II: Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm.

Block 2: Crop improvement

Unit I: Breeding objectives: Breeding objectives/ goals on the basis of yield, quality, stress tolerance, adaptation.

Unit II: Breeding methods: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses.

Block 3: Breeding achievements and future thrusts

Unit I: Breeding achievements: Breeding achievements in terms of released varieties, parentage, salient features.

Unit II: Future thrusts: Molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climate resilience

Crops

A. **Plantation crops**: Coconut, Arecanut, Cashew, Cocoa, Rubber, Oil palm, Coffee, Tea, Palmyrah, Betel vine

B. **Spice crops**: Black pepper, small and large cardamom, Ginger, Turmeric, Fenugreek, Coriander, Fennel, Cumin, Ajwain, Garlic, Nutmeg, Cinnamon, Clove, Allspice, Garcinia, Tamarind

VII. Practical

- Characterization and evaluation of germplasm;
- Floral biology, anthesis; pollen behaviour, fruit set;
- Practices in hybridization, selfing and crossing techniques;
- Polyploidy breeding;
- Mutation breeding;
- Induction of somaclonal variation and screening the variants;
- Evaluation of biometrical traits and quality traits;
- Salient features of improved varieties and cultivars;
- Screening for biotic and abiotic stresses;

- Bioinformatics;
- Exposure visits to research institutes for plantation and spice crops.

VIII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

IX. Learning outcome

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

- Develop the technical skill in breeding of plantation and spice crops
- Be able to start plantation and spice crop-based seed production/ nursery centres

X. Suggested Reading

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

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Ponnuswami *et al.* 2018. *Botany of Horticultural crops*. Narendra Publishing House, New Delhi Ponnuswami *et al.* 2018. *Spices*. Narendra Publishing House,New Delhi.

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Ramachandra *et al*. 2018. *Breeding of Spices and Plantation Crops*. Narendra Publishing House,New Delhi

Ravindran PN. 2002. *Cardamom, the genus Elettaria*. CRC press Ravindran PN. 2003. *Cinnamon and cassia.* CRC press Ravindran PN. 2004. *Ginger, the genus*

Zingiber. CRC press Ravindran PN. 2007. *Turmeric, the genus Curcuma*. CRC press

Sera T, Soccol CR, Pandey A, Roussos S. *Coffee Biotechnology and Quality.* Springer, Dordrecht.

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Sharangi AB and Datta S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.

Thampan PK. 1981. *Hand Book of Coconut Palm.* Oxford and IBH.

I. Course Title : Breeding of Medicinal and Aromatic Crops

II. Course Code : PSM 505

III. Credit Hours : (1+1)

IV. Why this course ?

Medicinal and aromatic crops play an important role in the national economy of India. For maximizing the production, productivity and quality of medicinal and aromatic crops, fundamental knowledge on breeding methods of the major crops is essential. This course will impart theoretical as well as hands-on experience to the learner on reproductive biology, breeding methods and breeding achievements in various medicinal and aromatic crops.

V. Aim of the course

To impart comprehensive knowledge on the principles and practices in the breeding of important medicinal and aromatic crops.

The course is organized as follows:

No	Blocks	Units
1	Genetic diversity	1. Species and cultivar diversity 2. Germplasm evaluation
2	Crop improvement	1. Breeding objectives 2. Breeding methods
3	Breeding achievements and future	1. Breeding achievements thrusts 2. Future thrusts

VI. Theory

Block 1: Genetic diversity

Unit 1: Species and cultivar diversity: Floral and reproductive biology, cytogenetics, male sterility, incompatibility, wild and cultivated species, popular cultivars.

Unit 2: Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm, IPR issues.

Block 2: Crop improvement

Unit 1: Breeding objectives: Breeding problems in medicinal and aromatic crops. Genetics of active principles, breeding objectives/ goals on the basis of yield, quality, stress tolerance, adaptation.

Unit 2: Breeding methods: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses.

Block 3

Unit 1: Breeding achievements: Breeding achievements in terms of released varieties, parentage, salient features.

Unit 2: Future thrusts: Molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climate resilience.

Crops

A. Medicinal crops: *Cassia angustifolia*, *Catharanthus roseus*, *Gloriosa superba, Coleus forskohlii*, *Stevia rebaudiana*, *Withania somnifera*, *Papaver somniferum*, *Plantago ovata*, *Chlorophytum* sp., *Rauvolfia serpentina*, *Aloe vera, Piper longum, Plumbago zeylanica*

B. Aromatic crops: Mint, geranium, patchouli, lemon grass, palmarosa, citronella, vetiver, Artemisia, ocimum, lavender, *Kaempferia galanga,* eucalyptus

VII. Practical

- Description of botanical features;
- Cataloguing of cultivars, varieties and species in medicinal and aromatic crops;
- Floral biology;
- Selfing and crossing;
- Evaluation of hybrid progenies;
- Induction of economic mutants;
- High alkaloid and high essential oil mutants;
- Evolution of mutants through physical and chemical mutagens;
- Introduction of polyploidy;
- Screening of plants for biotic and abiotic stress;
- *In-vitro* breeding in medicinal and aromatic crops.

VIII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Demonstration
- Exposure visits

IX. Learning outcome

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

- Develop the technical skill in breeding of medicinal and aromatic crops
- Be able to start medicinal and aromatic crop-based seed production/ nursery centres

X. Suggested Reading

Chadha KL and Gupta, R. 1995. *Advances in Horticulture.* Vol. XI. Malhotra Publ. House. Farooqi AA, Khan MM and Vasundhara M. 2001. *Production Technology of Medicinal and Aromatic Crops.* Natural Remedies Pvt. Ltd.

Gupta R.K. 2010. *Medicinal and Aromatic plants*. CBS publications Jain SK. 2000. *Medicinal Plants*. National Book Trust.

Julia F and Charters MC. 1997. *Major Medicinal Plants – Botany, Cultures and Uses*. Thomas Publ.

Kurian A and Asha Sankar M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

Ponnuswami *et al.* 2018. *Blossom biology of Horticultural crops*. Narendra Publishing House, New Delhi

Ponnuswami *et al.* 2018. *Botany of Horticultural crops*. Narendra Publishing House, New Delhi

A. Spice crops: Black Pepper, Cardamom, Ginger, Turmeric, Nutmeg, Cinnamon, Clove, Vanilla, Coriander, Fennel, Cumin, Fenugreek, Garlic

I. Practical

- Genus, species and cultivar features of various plantation and spice crops;

- Characterization based on descriptors;
- Characterization based on DUS guidelines;
- Study of sex forms and floral biology;
- Study of molecular markers;
- Exposure visits to national institutes including NBPGR.

II. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Demonstration
- Exposure visits

III. Learning outcome

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

- have thorough understanding on the systematics of plantation and spice crops

IV. Suggested Reading

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

Chadha KL and Gupta R. 1995. *Advances in Horticulture*. Vol. XI. Malhotra Publ. House. Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications,

Diwan AP and Dhakad NK. 1996. *Genetics and Development*. Anmol Publications Private Limited, New Delhi.

E-manual on Advances in Cashew Production Technology. ICAR –Directorate of Cashew Research, Puttur –574 202, DK, Karnataka

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Panda H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition).

Asia Pacific Business Press Inc.

Pillay PNR. 1980. *Handbook of Natural Rubber Production in India.* Rubber

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Ravindran PN. 2002. *Cardamom, the genusElettaria*. CRC press Ravindran PN. 2003. *Cinnamon and cassia.* CRC press Ravindran PN. 2004. *Ginger, the genus Zingiber*. CRC press Ravindran PN. 2007. *Turmeric, the genus curcuma*. CRC press

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Sera T, Soccol CR, Pandey A and Roussos S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.

Sethuraj MR and Mathew NT. 1992.*Natural Rubber: Biology, Cultivation and Technology*

(*Developments in Crop Science*). Elsevier Science.

Sharma G. 2009. *Systematics of fruit Crops*. New India Publishing House, India.

Strickberger MW. 2005. *Genetics* (III Ed). Prentice Hall, New Delhi, India

Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publishers

I. Course Title : Systematics of Medicinal and Aromatic Crops

II. Course Code : PSM 507

III. Credit Hours : (1+1)

IV. Why this course ?

Medicinal and aromatic crops play an important role in the national economy of India. For the crop improvement programme of these crops, fundamental knowledge on origin and development, evolutionary process, taxonomy and cytogenetics is most essential. This course will impart theoretical knowledge to the learner on the origin and distribution, evolutionary process, taxonomy and cytogenetics of various

medicinal and aromatic crops.

V. Aim of the course

To impart basic knowledge on the origin and development, evolutionary process, taxonomy, cytogenetics and genetic resources of medicinal and aromatic crops.

The course is organized as follows:

No	Blocks	Units
1	Origin and evolution	I Centre of origin
		II Systematics
2	Genetic diversity	I Species and cultivar diversity
		II Germplasm
3	Cataloguing	I Descriptors
		II DUS guidelines

VI. Theory

Block 1: Origin and evolution

Unit I: Centre of origin: Centre of origin, distribution, taxonomical status, phylogeny, chemotaxonomy.

Unit II: Systematics: Botany, cytology, ploidy status, sex forms, flowering and pollination biology, cytogenetics.

Block 2: Diversity

Unit I: Species and cultivar diversity: Wild and related species, cultivars.

Unit II: Germplasm: Indigenous and exotic germplasm.

Block 3: Cataloguing

Unit I: Descriptors: Biovarsity/ NBPGR descriptors and their salient features.

Unit II: DUS guidelines: DUS guidelines, molecular aspects of systematics.

Crops

1. Medicinal crops: Opium poppy, Isabgol, Aswagandha, Senna, Medicinal coleus,Glory Lily, Periwinkle, Sarpagandha, Long Pepper, Stevia, Safed musli, *Plumbago zeylanica*

2. Aromatic crops: Lemongrass, Citronella, Palmarosa, Vetiver, Mint, Patcholi, Geranium, Ocimum, Rosemary, Lavender, *Kaempferia galanga*, Eucalyptus

VII. Practical

- Genus, species and cultivar features of various medicinal and aromatic crops;
- Characterization based on descriptors;
- Characterization based on DUS guidelines;
- Study of sex forms and floral biology;
- Study of molecular markers;
- Exposure visits to national institutes including NBPGR.

VIII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Demonstration
- Exposure visits

IX. Learning outcome

After successful completion of this course, the students are expected to have thorough understanding on the systematics of medicinal and aromatic crops

X. Suggested Reading

Birel Shah and Seth AK. 2005. *Text book of Pharmacognosy and Phytochemistry*.

CBS Publishers and distributors, New Delhi.

Charles Burnham. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications

Diwan AP and Dhakad NK. 1996. *Genetics and Development*. Anmol Publications Private Limited, New Delhi.

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Skaria P Baby *et al.* 2007. *Aromatic Plants*. New India Publ. Agency.

Strickberger MW. 2005. *Genetics* (III Ed). Prentice Hall, New Delhi, India Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publishers.

Thakur RS, Pauri HS and Hussain A. 1989. *Major Medicinal Plants of India*. CSIR.

I. Course Title : Underexploited Plantation, Spice, Medicinal and Aromatic Plants

II. Course Code : PSM 508

III. Credit Hours : (2+0)

IV. Why this course ?

There are many number of underexploited plantation, spice, medicinal and aromatic crops which are becoming important in line with the major ones. They could very well be the major crops of tomorrow. This course will impart comprehensive knowledge to the learner on the importance and scientific production technology of various under utilised plantation, spice, medicinal and aromatic plants in India.

V. Aim of the course

To facilitate understanding on the importance and cultivation of underutilized and

lesser known plantation, spice, medicinal and aromatic plants. The course is organized as follows:

No	Blocks	Units
1	Importance and status	I Importance and uses
		II Status and future prospects
2	Production technology	I Propagation and varieties
		II Agro techniques
3	Harvest and post harvest Post harvest management	I Harvest indices management II

VI. Theory

Block 1: Importance and status

Unit I: Importance and Uses: Introduction, importance, economic parts used, traditional uses.

Unit II: Status and future prospects: Present status, origin, distribution and future prospects of under exploited PSMAs.

Block 2: Production technology

Unit I: Propagation and varieties: Propagation and nursery techniques, species varieties.

Unit II: Agro techniques: Climatic and soil requirements, planting and after care, weed and water management, manuring, plant protection.

Block 3: Harvest and post harvest management

Unit I: Harvest indices: Maturity indices, harvesting time, techniques, crop duration.

Unit II: Post harvest management: Primary processing, extraction and value addition, storage, active ingredients.

Crops

A. Plantation crops: Wattle, minor species of Areca, Coffea, Hevea

B. Spice crops: *Illicium verum*, *Myristica malabarica, M. beddomei, Cinnamomum tamala*, *C. malabatrum*, *Xanthoxylum* sp., *Curcuma caesia, C. aromatica, C. zedoaria, C. amada, Anethum graveolense, Hyssopus officinalis*, *Eringiumfoetidum, Pimpinella anisum, Artocarpus lacucha*.

C. Medicinal plants: *Flacourtia montana*, *Plectranthus aromaticus*, *Adhatoda* sp. *Hemidesmus indicus*, *Tinospora cordifolia*, *Gymnema sylvestre*, *Psoralea corylifolia*, *Eclipta alba*, *Aristalochia indica*, *Morinda citrifolia*, *Caesalpinia sappan*, *Terminalia chebula, T. bellerica, Phyllanthus amarus, Strychnos nuxvomica, S. indicum, S. xanthocarpum*, *Aegle marmelos*, *Alpinia* sp., *Hibiscus subdariffa, Anthocephalus kadamba, Costus* sp., *Kaempferia rotunda, K. parviflora, Picrorrhiza kurroa*, *Nardostachis jatamansi,Valeriana officinalis*, *Swertia chiraita, Aconitum* sp., *Salvia officinalis*, *Centella asiatica, Bixa orellana, Bacopa monnieri*

D. Aromatic plants: *Bursera* sp., *Commiphora wightii*, *Ocimum kilimandjaricum, Melaleuca, Michaelia champaka*, *Rosa damascena, Cananga odorata,* marjoram, chamomile

VII. Practical

- Botanical characteristics of species and varieties of various underexploited plantation, spice, medicinal and aromatic plants;
- Economic parts and their products;
- Propagation and nursery techniques;
- Harvesting and primary processing of under utilised PSMAs;
- Exposure visits to institutes, botanical gardens, herbal gardens and distillation units.

VIII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Demonstration
- Exposure visits

IX. Learning outcome

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

- be thorough with the importance and commercial production technology of underutilized and lesser known plantation, spice, medicinal and aromatic plants.
- be able to startunderutilized and lesser known plantation, spice, medicinal and aromatic plants-based enterprises

X. Suggested Reading

Atal CK and Kapur BM. *Cultivation and Utilization of Aromatic plants*. R.R.L. Jammu Barche Swati. 2016. *Production technology of spices, aromatic, medicinal and plantation crops*.

New India Publishing Agency, New Delhi

Chadha KL and Gupta R. 1995. *Advance in Horticulture.* Vol. XI. *Medicinal and Aromatic Plants.*

Malhotra Publ. House.

CSIR, *The Wealth of India*. Volume A-Z CSIR

Farooqui AA, Khan MM and Sreeramu BS. 1997. *Cultivation of Medicinal and Aromatic Crops in India.* Naya Prokash.

Jain SK. 1979. *Medicinal Plants.* National Book Trust.

Kurian A and Asha Sankar M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

Nybe EV, Mini Raj N and Peter KV. 2007. *Spices*. Horticulture Science Series, New India Publ.

Agency.

Peter KV. *Under exploited and underutilized Horticulture crops*. Volume I-IV. New India Publication Agency.

Ponnuswami *et al.* 2018. *Blossom biology of Horticultural crops*. Narendra Publishing House, New Delhi.

Ponnuswami *et al.* 2018. *Botany of Horticultural crops*. Narendra Publishing House, New Delhi Ponnuswami *et al*. 2018. *Medicinal Herbs and Herbal Cure*. Narendra Publishing House, New

Delhi

Sharangi AB and Datta S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.

Sharangi AB, Bhutia PH, Chandani Raj A and Sreenivas M. 2018. *Underexploited spice crops: Present status, agrotechnology and future research directions.* Apple Academic Press (Taylor and Francis Group), Waretown, NJ, USA, p.326.

Sivarajan VV and Balachandran I. 1994. *Ayurvedic Drugs and their Plant Sources.* Oxford and IBH.

I. **Course Title : Growth and Development of Plantation, Spice, Medicinal and Aromatic Crops**

II. **Course Code : PSM 509**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Understanding on growth and development of plantation, spice, medicinal and aromatic crops is vital towards quality production as well as yield. Fundamental knowledge on developmental physiology, biology and biochemistry and the associated changes is most essential. This course will impart theoretical as well as hands-on experience to the learner on these aspects of PSMA crops for improving their productivity.

V. Aim of the course

To impart comprehensive knowledge on the growth, developmental stages and crop regulation to increase the productivity in PSMAs

The course is organized as follows:

No	Blocks	Units	
1	Growth and development	I	Stages of growth
		II	Growth pattern
		III	Assimilate partitioning
2	Canopy management	I	Canopy management
		II	Plant bio regulators
3	Developmental physiology and	I	Vegetative phase biochemistry
		II	Flowering and fruit set

VI. Theory

Block 1: Growth, development, assimilate partitioning and plant bio regulators

Unit I: Stages of growth: Growth and development, definitions, components, photosynthetic productivity, different stages of growth, growth curves, growth analysis, morphogenesis in PSMAs.

Unit II: Growth pattern: in annual, semi-perennial and perennial crops, growth dimorphism, environmental impact on growth and development: effect of light, temperature, photoperiod.

Unit III: Assimilate partitioning: Assimilate partitioning during growth and development, influence of water and mineral nutrition.

Block 2: Canopy management

Unit I: Canopy management: Canopy management for conventional and high density planting pruning, training, chemicals, crop regulation for year round and off season production in PSMAs.

Unit II: Plant bio regulators: plant bio regulators- auxins, gibberellins, cytokinins, ethylene, inhibitors and retardants, basic functions, biosynthesis and role in crop growth and development.

Unit I: Vegetative phase: Developmental physiology and biochemistry during dormancy, bud break, juvenility.

Unit II: Flowering and fruit set

Physiology of flowering, photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism, pollination, fertilisation, fruit set, fruit drop, fruit growth, ripening, seed development in PSMAs.

Unit III: Growth and development process during stress: Growth and development process during stress, production of secondary metabolites, molecular and genetic approaches in growth and development.

VII. Practical

- Dormancy mechanisms in seeds, seed rhizomes;
- Techniques of growth analysis;
- Evaluation of photosynthetic efficiency under different environments;
- Technologies for crop regulation in cashew, coffee, cocoa, etc.;
- Root shoot studies, flower thinning, fruit thinning;
- Crop regulation for year round production;
- Use of growth regulators in PSMA crops.

VIII. Teaching Methods/ Activities

- Lectures
- Assignments (Reading/ Writing)
- Demonstrations
- Exposure visits

IX. Learning outcome

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

- have thorough understanding on growth and development of PSMA crops

- will enable them to formulate crop regulation strategies for productivity enhancement.

x. Suggested Reading

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

Buchanan BW. Gruiessam and Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*.

John Wiley and Sons.

E- manual on Advances in Cashew Production Technology. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka

Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*.Wiley.

Fosket DE. 1994. *Plant Growth and Development: A Molecular approach*. Academic Press. Leoplod AC and Kriedermann PE. 1985. *Plant Growth and Development.* 3rdEd.McGraw-Hill Panda H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.

Panda H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition).

Asia Pacific Business Press Inc.

Pillay PNR. 1980. *Handbook of Natural Rubber Production in India.* Rubber Research Institute, Kottayam. pp.668

Ravindran PN. 2000. *Black pepper*, *Piper nigrum*. CRC press Ravindran PN. 2002. *Cardamom, the genus Elettaria*. CRC press Ravindran PN. 2003. *Cinnamon and cassia.* CRC press Ravindran PN. 2004. *Ginger, the genus Zingiber*. CRC press Ravindran PN. 2007. *Turmeric, the genus curcuma*. CRC press

Roberts JS Downs and P Parker. 2002. *Plant Growth Development*. In: *Plants* (L. Ridge, Ed.),

pp. 221-274, Oxford University Press

Salisbur FB and Ross CW. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.

Sera T, Soccol CR, Pandey A. and Roussos S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.

Sethuraj MR and Mathew NT. 1992. *Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science)*. Elsevier Science.

I. Course Title : Biochemistry of Plantation, Spices, Medicinal and Aromatic Crops

II. Course Code : PSM 510

III. Credit Hours : (2+1)

IV. Why this course ?

Postharvest physiology and biochemistry of plantation, spice, medicinal and aromatic crops contributes immensely towards quality improvement in crude as well as processed products. Fundamental knowledge on biochemistry of various crops is also essential for formulating their management practices in the field. This course will impart theoretical as well as hands-on experience to the learner on the biochemistry of PSMA crops.

V. Aim of the course

To impart comprehensive knowledge on the biochemistry, production of primary and secondary metabolites and the extraction of bioactive principles from PSMAs

The course is organized as follows:

No Blocks Units

1	Post harvest physiology	I Physiological and biochemical changes
		II Contaminants
2	Value addition	I Value added products
		II Quality standards
3	Extraction techniques	I Extraction techniques
		II Plant tissue culture

VI. Theory

Block 1: Post-harvest physiology

Unit I: Physiological and biochemical changes: Maturity indices, changes during ripening, processing, factors affecting quality. Secondary metabolites and their biosynthetic pathways, factors affecting production of secondary metabolites.

Unit II: Contaminants: Adulterants, and substitutes, sources of contamination-microbial, heavy metal, pesticide residues in PSMAs.

Block 2: Value addition

Unit I: Value added products: Fixed oils, essential oils, dyes, oleoresins, aroma chemicals and other value added products, their content, storage, medicinal and pharmacological properties, use in the food, flavour perfumery and pharmaceutical industries.

Unit II: Quality standards: Quality standards of raw materials and finished products.

Block 3: Extraction techniques

Unit I: Extraction methods: Basic and advanced extraction techniques in PSMAs-Soxhlet, SCFE, Membrane extraction. Chemical characterization-HPTLC, GCMS, LCMS, NMR.

Unit II: Plant tissue culture: Plant tissue cultures in the industrial production of bioactive plant metabolites. Cell suspension culture systems for large scale culturing of plant cells and production of secondary metabolites. Advantages of cell culture over conventional extraction techniques.

VII. Practical

- Biochemical characterisation;
- Detection of adulterants and substitutes;
- Extraction and quantification of secondary metabolites;
- Chromatographic separation of the products;
- Quality assurance;
- Testing the product;
- Exposure visit to leading industries;
- Assessment of antimicrobial properties;
- *In-vitro* production of secondary metabolites.

VIII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Demonstration
- Exposure visits

IX. Learning outcome

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

- develop the technical know- how on postharvest biochemistry of plantation, spice, medicinal and aromatic crops.

X. Suggested Reading

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

Daniel M and Mammen D. 2016. *Analytical methods for medicinal plants and economic botany*.

Scientific publishers.

Das K. 2013. *Essential oils and their applications*. New India Publishing Agency, New Delhi.

E-manual on Advances in Cashew Production Technology. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka.

Hammon JM and Yusibov V. 2000. *Plant Biotechnology*: New Products and application. Springer- Verlag.

Orhan I. 2012. *Biotechnological Production of Plant Secondary Metabolites*. Bentham Science Publishers.

Panda H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.

Panda H. 2016. The Complete Book on Cultivation and Manufacture of Tea (2nd Revised Edition). Asia Pacific Business Press Inc.

Parimelzhagan T. 2013. *Turning plants into medicines: Novel approaches*. New India Publishing Agency, New Delhi.

Pillay PNR. 1980. *Handbook of Natural Rubber Production in India.* Rubber Research Institute, Kottayam. pp.668.

Ponnuswami *et al.* 2018 Medicinal Herbs and herbal cure. Narendra Publishing House, New Delhi.

Raaman N. 2006. *Phytochemical techniques*. New India Publishing Agency, New Delhi. Raju R Wadekar. 2015. *Pharmacognosy and phytochemistry*, Event publishing house.

Ramawat KG. 2007. *Biotechnology: secondary metabolites: plants and microbes*. Science Publishers.

Ranjal Kandall. *Bioactive compounds and genomic study of medicinal plants*. LAMBERT Academic Publishing.

Sera T, Soccol CR, Pandey A and Roussos S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.

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Trivedi C. 2004. *Herbal drugs and biotechnology*. Pointer Publishers.

Waghulkar VM. 2012. *Quality assurance techniques in pharmaceuticals*. New India Publishing Agency, New Delhi.

I. **Course Title : Biodiversity and Conservation of Plantation, Spices Medicinal and Aromatic Crops**

II. **Course Code : PSM 511**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

India is the homeland of several plantation, spice, medicinal and aromatic crops. Biodiversity conservation is considered as the primary step in protecting the gene pool available in these crops. Fundamental knowledge on centres of diversity, germplasm evaluation, documentation, data base management and cataloguing is most essential. This course will impart theoretical as well as hands-on experience to the learner on these areas.

V. Aim of the course

To impart basic knowledge on natural as well as agro bio diversity, its value and conservation strategies with respect to PSMAs.

The course is organized as follows:

No	Blocks	Units	
1	Plantation and spice crops	I	Biodiversity
		II	Germplasm collection and quarantine
		III	Documentation and cataloguing
		IV	National and international issues
2	Medicinal and aromatic crops	I	Biodiversity
		II	Germplasm collection and quarantine
		III	Documentation and cataloguing
		IV	National and international issues

VI. Learning outcome

After successful completion of this course, the students are expected to develop thorough understanding on biodiversity conservation of plantation, spice, medicinal and aromatic plants.

VII. Theory

Block 1: Plantation and Spice crops

Unit I: Biodiversity: Biodiversity, issues and goals, centres of origin of Plantation and spice crops, primary and secondary centres of genetic diversity.

Unit II: Germplasm collection and quarantine: Exploration and germplasm collection, planning and logistics, exchange of germplasm, plant quarantine principles, regulations plant quarantine systems in India. Components of germplasm evaluation, descriptor lists. Conservation of genetics resources, Concept of base and active collections, long and short term storage of Plantation and spice crops, gene bank management.

Unit III: Documentation and cataloguing: Recent approaches and role of biotechnology in PGR conservation documentation and data base management, cataloguing gene bank information. Molecular markers in characterisation of plant genetic resources. GIS in biodiversity mapping.

Unit IV: National and international issues: Genetic resources management of Plantation and Spice crops in India and in International perspective. Utilization and achievements in major crops. Concepts of rarity, threat, endangerment and extinction in major plantation and spice crops. Bio

diversity concerns, national and international regulations, conservation networks. Good collection practices, domestication, PPV and FRA and DUS testing. Geographical indication, Biodiversity act and biodiversity legislations.

Block II: Medicinal and aromatic crops

Unit I: Biodiversity: Biodiversity, issues and goals, centres of origin of medicinal and aromatic crops, primary and secondary centres of genetic diversity.

Unit II: Germplasm collection and quarantine: Exploration and germplasm collection, planning and logistics, exchange of germplasm, plant quarantine principles, regulations plant quarantine systems in India. Components of germplasm evaluation, descriptor lists. Conservation of genetics resources, Concept of base and active collections, long and short term storage of Plantation and spice crops, gene bank management.

Unit III: Documentation and cataloguing: Recent approaches and role of biotechnology in PGR conservation documentation and data base management, cataloguing gene bank information. Molecular markers in characterisation of plant genetic resources. GIS in biodiversity mapping.

Unit IV: National and international issues: Genetic resources management of Plantation and Spice crops in India and in International perspective. Utilization and achievements in major crops. Concepts of rarity, threat, endangerment and extinction in major plantation and spice crops. Bio diversity concerns, national and international regulations, conservation networks. Good collection practices, domestication, PPV and FRA and DUS testing. Geographical indication, Biodiversity act and biodiversity legislations.

VIII. Practical

- Collection and identification of different plantation, spice, medicinal and aromatic plants from natural sources;
- Preparation of herbarium;
- Botanical and phyto-chemical grouping of PSMAs;
- Classification of PSMAs based on plant parts used;
- Documentation of germplasm;
- Maintenance of passport data and other records;
- Field explorations;
- Detection of adulterants and substitutes in PSMAs;
- Ethno botanical studies in tribal areas;
- Planning and layout of herbal gardens;
- Exposure visits to herbaria, herbal gardens and important organisations engaged in collection and utilization of PSMAs.

IX. Teaching Methods/ Activities

- Lectures
- Assignments (Reading/ Writing)
- Demonstrations

- Exposure visits

x. Suggested Reading

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

Choudhari AB. *Megadiversity Conservation: Flora, Fauna and Medicinal Plants of India's hot spots.*

Devi AR, Sharangi AB, Acharya SK and Mishra GC. 2017. *Coriander in Eastern India: The landraces and genetic diversity.* Krishi Sanskriti Publications. New Delhi. ISBN: 978-93- 85822-48-3.

E- manual on Advances in Cashew Production Technology. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka

Kassahun Beemnet, Jemal Omar Sherif, TessemaTsion, Abate Solomon. 2009. *Production, Processing and utilization of Aromatic Plants.* EIAR.

Khan JB and Singh GP. 2012. *Biodiversity Management and Conservation* LAMBERT Negi SS. *Biodiversity of India and its Conservation.*

Panda H. 2002. *Medicinal Plants Cultivation and their Uses.* Asia Pacific Business Press. Panda H. 2005. *Aromatic Plants Cultivation, Processing and Uses.* Asia Pacific Business Press Panda H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.

Panda H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition).

Asia Pacific Business Press Inc.

Panda H. 2017. *Herbal andAromatic Plants Cultivation, Processing, Utilisation and Applications*.

Discovery publishing house, New Delhi

Pillay PNR. 1980. *Handbook of Natural Rubber Production in India.* Rubber Research Institute, Kottayam. pp.66

Ponnuswami *et al.* 2018. Medicinal Herbs and herbal cure. Narendra Publishing House, New Delhi

Ponnuswami *et al.* 2018. Spices. Narendra Publishing House, New Delhi

Pullaiah T. 2011. *Biodiversity in India* Vol.5.Daya Publishing house

Rajak RC and Rai MK. *Herbal Medicines, Biodiversity and Conservation strategies*. IBH. Ramakrishnan N. 2018. *Biodiversity in Indian Scenario*. Daya publishing house.

Sera T, Soccol CR, Pandey A, Roussos S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.

Sethuraj MR and Mathew NT. 1992. *Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science)*. Elsevier Science.

Thirugnanakumar. 2018. *Genetic diversity and phenotypic stability in crop plants*. New India Publishing Agency, New Delhi

Trivedi PC. *Medicinal Plants: Utilization and Conservation.*

Horticultural Sciences
– Post-harvest Management

Postharvest Management is an interdisciplinary science and technology applied to horticulture produce after its harvest for its protection, conservation, processing, packaging, distribution, marketing, and utilization to meet the food and nutritional requirements of people. India is the 2nd largest producer of fruits and vegetables in the world. Several studies suggest that around 30–40% of produced fruits and vegetables are lost before they reach final consumer. These losses occur during different stages of harvesting, handling, packaging, transportation, in wholesale and retail markets. Moreover, only 2.5% of the produce is processed, to minimize the losses of fruits, vegetables, flowers, plantation and spice crops and to increase the farmers income there by guaranteeing the national food and nutritional security. Postharvest losses vary greatly among commodities and production areas and seasons. There is a need for man power with specialization in postharvest management to meet and tackle the above demands and to develop an action plan for establishing an effective post harvest research and extension programme to strengthen the link between researchers and extensionists. Looking to the importance of this sector,the Post Harvest Technology (Horticultural Crops), was considered as an independent discipline till the recent past, but it was deleted as independent discipline horticulture since 2009. However, 22 universities have continued department of Post-Harvest Management/ Technology and in some universities the discipline combined with Fruit Science department. The post-harvest agri/ horticulture management of perishable commodities like horticultural crops, which are primarily physiological in nature, is distinctly different than the PHT of the food grains, fish, dairy and meat. It was therefore suggested that an independent discipline of Postharvest Management should be considered in horticulture discipline.

There is a need for post-graduate students to conduct in-depth research on several aspects of postharvest management in order to reduce the losses in quality and quantity and to maintain safety of the produce between harvest and consumption and also to support the farmers and encourage entrepreneurs thereby providing employment opportunities as well as conducting research programmes after obtaining their degrees. They would serve in different universities as teaching faculty and in research stations as scientists and also can serve the nation by creating employment as entrepreneurs. M.Sc. and Ph.D. syllabi in Postharvest Management were drafted through a series of meetings/ workshops conducted at VCSGUUHF, Uttarakhand, BCKV, Mohanpur and IARI, New Delhi.

Courses have been designed emphasising the following thrust areas: Storage methods to extend shelf life and to enhance the nutritional compounds in functional foods, Standardization of processing technologies (drying, canning, freezing, etc.) for extending shelf life, Preserve the phytochemical and nutritional content of fruits and vegetables at every step of the food distribution system, Waste processing and value addition in fruits, Integrating available technologies (bio-, info- and nanotechnology) through a system, Pre and Post-harvest treatments to enhance shelf life, Testing bioactive compounds from fruits and vegetables and their action against pathogens, Safe and minimal processing, Use of robotics for harvesting, packing and handling of individual through bulk items; managing logistics and supply chains effectively and efficiently, Physiological and biochemical systems

regulating product deterioration and senescence, Innovations in packaging and storage technology of fresh produce, Active and smart packaging film for food and Postharvest treatment, Studies of reusable/ recyclable packages, Inexpensive and safer ripening systems, Low-cost cooling methods and Sanitation and food safety practices.Besides due importance has been given while designing the course contents towards the national priorities and policies, viz., skill developmet and employment generation, doubling farmers income, nutritional security and minimising food loss/ waste.

Course Title with Credit Load

M.Sc. (Hort.) in Post-Harvest Management

Course Code	Course Title	Credit Hours
PHM 501 *	Postharvest Management of Horticultural Produce	2+1
PHM 502*	Postharvest Physiology and Biochemistry of Perishables	2+1
PHM 503	Packaging and Storage of Fresh Horticultural Produce	1+1
PHM 504	Packaging and Storage of Processed Horticultural Produce	1+1
PHM 505*	Principles and Methods of Fruit And Vegetable Preservation	2+1
PHM 506	Laboratory Techniques in Postharvest Management	1+2
PHM 507*	Processing of Horticultural Produce	2+2
PHM 508	Quality Assurance, Safety and Sensory Evaluation of Fresh and Processed Horticultural Produce	2+1
PHM 509	Functional Foods from Horticultural Produce	2+0
PHM 510	Marketing and Entrepreneurship in Postharvest Horticulture	1+1
	Minor Courses (08 credits)	08
	Supporting Courses (06 credits)	06
	Common compulsory courses (05 credits)	05
PHM 591	Seminar	0+1
PHM 599	Research	0+30
	Total	**70**

*Compulsory among major courses

Course Contents

M.Sc. (Hort.) in Post-harvest Management

I. **Course Title : Postharvest Management of Horticultural Produce**

II. **Course Code : PHM 501**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Fruits and vegetables are perishable crops that suffer great losses both in quantity and quality after harvest. These produce require integrated approach to arrest their spoilage and overcome the present day challenges that assimilates millions of tons annually. Lack of postharvest awareness and absence of sufficient and functioning equipment in the postharvest chain result in serious postharvest losses in developing countries. Clear and comprehensive understanding of postharvest deteriorative factors is necessary to overcome these challenges. Pre and postharvest management such as good cultural practices, use of improved varieties, good handling practices pre and postharvest, temperature and relative humidity management, storage atmosphere management, use of permitted chemicals, design of appropriate packaging materials and storage structures are some of the control measures use in reducing postharvest losses. Hence this customized course

V. Aim of the course

To impart comprehensive knowledge on management of horticultural produce thus extending the post-harvest life of the produce by various treatments.

The course is organized as follows:

No	Blocks	Units
1	Postharvest management of produce	I Importance and scope horticultural II Regulation of ripening III Treatments for extending shelf life IV Handling system and marketing of horticultural crops

VI. Theory

Block 1: Postharvest Management of Horticultural Produce

Unit I: History, Importance and scope of Postharvest technology of horticultural produce. Nature and structure of horticultural produce. Pre and Postharvest losses and their causes.

Unit II: Climacteric and non-climacteric fruits. Regulation of ripening by use of chemicals and growth regulators. Control of sprouting, rooting and discoloration in vegetables.

Unit III: Maturity indices for harvest. Harvesting and harvesting tools. Curing

in roots and tubers. Prepackage Operation: Preecooling, washing, sorting, grading of horticultural perishables for local markets and export. Postharvest handling of spices, plantation crops, medicinal and aromatic plants. Equipments for washing, sizing, grading.

Unit IV: Pre and Postharvest treatments for extending storage life/ vase life. VHT, irradiation treatment, skin coating, degreening, etc. Prepackaging, Packaging techniques for local market and export. Standardsand specifications for fresh produce.

Unit V: Postharvest handling system for horticulture crops of regional importance. Principles of transport, modes of transportation, types of vehicles and transit requirements for different horticultural produce. Marketing: Factors influencing marketing of perishable crops, marketing systems and organizations.

VII. Practical

- Study of maturity indices for harvest of fruits, vegetables, spices and plantation crops;
- Protective skin coating with wax emulsion and pre and Postharvest treatment with fungicides, chemicals and growth regulators to extend the shelf life of fruits and vegetables;
- Prepackaging of perishables;
- Extension of vaselife of cut flowers by use of chemicals and growth regulators;
- Control of sprouting of potato and onion by using growth regulators;
- Study of modern harvesting, sorting and grading equipments;
- Study of effect of pre-cooling on shelf-life and quality of fresh fruits, vegetables and flowers;
- Visit to packaging centers;
- Visit to local markets, cooperative organizations, super markets dealing

with marketing of Perishables.

VIII. Teaching Methods/ Activities

- Lectures
- Assignments (Reading/ Writing)
- Exposure visits
- Student presentation
- Group Work/ seminars

IX. Learning outcome

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

- Regulation of ripening by use of chemicals and growth regulators
- Pre and Postharvest treatments for extending storage life/ vase life
- Standards and specifications for fresh produce

X. Suggested Reading

Bhattacharjee SK and Dee LC. 2005. *Postharvest technology of flowers and ornamental plants*.

Pointer publishers, Jaipur.

Chattopadhyay SK. 2007. *Handling, transportation and storage of fruit and vegetables*. Gene- Tech books, New Delhi.

FAO. 2007. *Handing and Preservation of Fruits and Vegetables by Combined methods for Rural Areas*-Technical Manual. FAO Agr.Ser.Bull., 149.

Kader AA. 1992. *Postharvest technology of horticultural crops*. 2nd ed university of California. Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest Biology and Technology of Fruits, Vegetables and Flowers*, Wiley-Blackwell, ISBN: 9780813804088.

Pruthi JS. 2001 (Reprint). *Major spices of India crop management and Postharvest technology*. ICAR, NewDelhi

Stawley J Kays. 1998. *Postharvest physiology of perishable plant products*. CBS publishers. Sudheer KP, Indira V. 2007. *Postharvest Technology of Horticultural Crops*, Peter K.V. (Ed.),

New India Publishing Agency, ISBN 9788189422431.

Sunil Pareek (Ed.) 2016. *Postharvest Ripening Physiology of Crops*, CRC Press, ISBN 9781498703802.

Thompson AK. (Ed.) 2014. *Fruit and Vegetables: Harvesting, Handling and Storage* (Vol. 1 & 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.

Verma LR and Joshi VK. 2000. *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.Wills RBH and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.

Wills RBH and Golding J. 2017. *Advances in Postharvest Fruit and Vegetable Technology*, CRC Press, ISBN 9781138894051.

Websites:

Horticulture-Post harvest management CSIR-NISTADS http://www.nistads.res.in/indiasnt2008/ t6rural/t6rur13.htm

Post harvest technology- MANAGE http://www.manage.gov.in/ftf-itt/prgReports/iihr.pdf Role of post-harvest management

http://www.fao.org/3/y5431e/y5431e02.htm

I. **Course Title : Postharvest Physiology and Biochemistry of Perishables**

II. **Course Code : PHM502**

III. **Credit Hours : (2+1)**

IV. **Why this course ?**

Immediately after harvesting, vegetables and fruits are subjected to the active processes of degradation. Numerous physiological and biochemical processes continuously change the original composition of the crop until which decrease the shelf life of the produce. Postharvest physiology is the scientific study of the physiology of living plant tissues after picking. It is very much necessary to learn about it as has direct applications to postharvest handling in establishing the storage and transport conditions that prolong shelf life. Hence this customized course.

V. Aim of the course

To impart comprehensive knowledge on physiology of horticultural produce after harvest and to understand different physiological processes like respiration ripening

The course is organized as follows:

No	Blocks	Units
1	Biochemistry of perishable	I. Structure and composition of horticultural produce
		II Biochemical Changes after harvest
2	Postharvest physiology of	I Maturity, Ripening and respiration

perishables

II Respiratory climacteric and transpiration

III Factors affecting shelf-life

VI. Theory

Block 1: Biochemistry of perishables

Unit I: Introduction, biochemical structure and composition of fruits, vegetables and ornamentals.

Unit II: Biochemical changes during development and ripening. Structural Deterioration of the Produce-cell wall degradation, change in membrane lipid.: Biosynthesis of ethylene and its regulation. Ethylene action and ripening processes, its perception-action and regulation.

Block 2: Postharvest physiology of perishables

Unit I: Determining maturity and maturity indices. Ripening processes: events of ripening and factors affecting them.

Unit II: Physiology of preharvest and postharvest; factors affecting shelf-life and quality of fruits, vegetables and ornamentals.

Unit III: Respiration: respiratory climacteric, its significance. Transpiration and water stress during postharvest. Postharvest oxidative stress: active oxygen species, AOS generation, physiological effects on horticultural commodity, control of oxidative injury.

VII. Practical

- Determination of physical parameters like specific gravity, fruit firmness, etc.;
- Determination of physiological loss in weight;
- Determination of chemical constituents like sugar, starch, pigments, Vitamin C, acidity during maturation and ripening in fruits/ vegetables;

- Estimation of ethylene evolved from ripening fruits;
- Delay/ Hastening of ripening by ethylene treatments;
- Determination of firmness, TSS, moisture, Titratable acid, sugar, protein, starch, fats, chlorophyll, carotene, anthocyanin, phenols and tannins;
- Measurement of respiration and ethylene evaluation.

VIII. Teaching Methods/ Activities

- Lectures
- Assignments (Reading/ Writing)
- Exposure visits
- Student presentations
- Group Work

IX. Learning outcome

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

- Understand about different factors affecting shelf life
- Processes of respiration and ripening
- Biosynthesis of ethylene and its action on ripening

X. Suggested Reading

Chadha KL and Pal RK. 2015. *Managing postharvest quality and losses in horticultural crops*.

Vol-1: General Issues, 1-231p Astral International (P) Ltd., New Delhi

Chadha KL and Pal RK. 2015. *Managing postharvest quality and losses in horticultural crops*.

Vol-2: Fruit Crops, 253-561p Astral International (P) Ltd., New Delhi

Chadha KL and Pal RK. (2015) *Managing postharvest quality and losses in horticultural crops*. Vol-3: Vegetables, Flowers and Plantation Crops, 581-727p Astral International (P) Ltd., New Delhi

Hodges DM. 2003. *Postharvest Oxidative Stress in Horticultural Crops*, 1st Edition, ISBN 9781560229636

Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest Biology and Technology of Fruits, Vegetables and Flowers*, Wiley-Blackwell, ISBN: 9780813804088.

Sunil Pareek (Ed.) 2016. *Postharvest Ripening Physiology of Crops*,CRC Press, ISBN 9781498703802.

Thompson AK. 1995. *Post harvest Technology of fruits and vegetables*. Blackwell Sciences Verma LR and Joshi VK. 2000. *Postharvest Technology of Fruits and Vegetables: Handling,*

Processing, Fermentation and Waste Management. Indus Publishing Company, New Delhi, India. ISBN 8173871086.

Wills RBH and Golding J. 2017. *Advances in Postharvest Fruit and Vegetable Technology*, CRC Press, ISBN 9781138894051.

Wills RBH and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.

Websites

Food and Agriculture Organization http://www.fao.org/home/en/ Respiration in plants http://ncert.nic.in/ncerts/l/kebo114.pdf

Ethylene biosynthesis and its response http://www.biologydiscussion.com/plants/hormones-plants/ethylene-biosynthesis-and-its-responses-plant-hormones/25986

I. **Course Title : Packaging and Storage Offresh Horticultural Produce**

II. **Course Code : PHM 503**

III. **Credit Hours : (1+1)**

IV. **Why this course ?**

Being a potential source of minerals, vitamins and proteins and carbohydrates, horticultural commodities play an important role in the health and nutritional security of the people. Proper packaging and storage will utilize market surplus during glut season and thus give boost to the food industry. Horticultural produce is highly perishable particularly under tropical conditions of India. The spoilage of these commodities can be reduced to a large extent by this storage technology. Hence this customized course

V. Aim of the course

To acquaint with the different storage systems and packaging systems for perishable horticultural produce.

The course is organized as follows:

No	Blocks	Units
1	Storage systems	I. Importance of storage II. Different methods of storage III. Modified methods of storage
2	Packaging	I. Importance of packaging and packaging methods II. New technologies in packaging

VI. Theory

Block 1: Storage Systems

Unit I: Importance of storage of horticultural produce, present status and future scope. Principles and methods of storage – field storage structures and designs for bulk storage of horticultural produce- onion and potato, etc. Evaporative cool chambers. Physiological changes during storage.

Unit II: Refrigerated storage – principles of refrigeration, types of refrigerants, refrigeration equipments. Cold storage rooms – Calculation of refrigeration load. Storage requirements of different fruits, vegetables, flowers. Storage disorder symptoms and control.

Unit III: Controlled or modified atmosphere (CA/MA) storage – principles, uses, structures and equipments, methods and requirements. Effect of CA storage on the physiology of stored produce. Hypobaric storage-principle, uses, and requirements. Storage disorders.

Block 2: Packaging

Unit I: Importance of packaging of fresh and processed horticultural produce, present status and future scope. Gaps in packaging concepts. Packaging requirements of fresh horticultural produce. Packaging patterns and methods. Food packaging systems: Different forms of packaging such as rigid, semi-rigid, flexible forms. Traditional, improved and specialized packages. Paper based packages: corrugated fibre board boxes – raw material and types of boxes. Flexible packaging materials – types and their properties. Consumer and intermediate flexible bulk containers. Testing of flexible packaging material. Barrier properties of packaging materials.

Unit 2: New technology in packaging – stretch wrapping system, vacuum packaging, gas packaging, controlled atmosphere (active and intelligent) packaging, vibra packaging, skin packaging, shrink packaging, form- fill-seal packaging, Packaging machines.Quality control and safety aspects of packaging materials.

VII. Practical

- Study of special storage structures for bulk storage of onion/ potato, etc.;
- Study of storage behavior of different fruits and vegetables in zero energy cool chamber;
- Determination of refrigeration requirements (capacity) for given quantity of fruits and vegetables;
- Study of storage behaviour of different fruits and vegetables in cold room;
- Study of chilling injury and storage disorders;
- Study of shelf-life of fruits and vegetables in modified atmosphere packaging. Visit

to special storage structures, cold storage units. Study of types of packaging materials, types of plastic films and their properties;

- Determination of water vapour transmission rate (WVTR) and gas transmission rate (GTR) of packaging material;
- Applications of packaging material for fresh fruits and vegetables, beverages, spice products;
- Determination of shelf-life of fresh products in different types of packages;
- Study of packaging machines – vacuum packaging machine, shrink wrapping machine, double seamer, etc. Visit to packaging unit.

VIII. Teaching Methods/ Activities

- Lectures
- Assignments (Reading/ Writing)
- Exposure visits
- Student presentations
- Group Work/ seminars

IX. Learning outcome

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

- Importance of storage of horticultural produce
- Different methods of storage
- Importance of packaging for fresh horticultural produce
- Different methods of packaging

X. Suggested Reading

Ahvenainen R. 2003. Novel Food Packaging Techniques, CRC Press, ISBN 0849317894. Ahvenainen R. 2001. *Novel Food Packaging Techniques*. CRC.

Burg SP (Ed.). 2004. *Postharvest physiology and hypobaric storage of fresh*

produce, CABI Publishing, ISBN 0851998011.

Chattopadhya SK. 2007. *Handling, transportation and storage of fruits and vegetables*. Gene- Tech books, New Delhi.

Chandra GopalaRao. 2015. *Engineering for Storage of Fruits and Vegetables*; Academic Press, 1st Edition.

Coles R, McDowell D and Kirwan MJ. (Eds.). 2003. *Food Packaging Technology*, Blackwell Publishing, ISBN 1841272213.

Mahadevaiah M and Gowramma RV. 1996. *Food packaging materials*. Tata McGraw Hill. Painy FA. 1992. *A handbook of food packaging*. Blackie Academic.

Pantastico B. 1975. Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables. AVI Publ.

Robertson GL. (Ed.). 2010. Food packaging and shelf life: a practical guide CRC Press, ISBN 9781420078442.

Thompson AK. 2010. *Controlled atmosphere storage of fruits and vegetables* (2nd Edition), CABI International, ISBN 9781845936464.

Wilson CL. (Ed.). 2007. *Intelligent and active packaging for fruits and vegetables*, CRC Press, ISBN 9780849391668.

Websites

Storage practices and structures UCANR http://ucanr.edu/datastoreFiles/234-1303.pdf

Low cost storage technologies for preservation-IARI http://www.iari.res.in/download/pdf/ story4_eng.pdf

https://energypedia.info/wiki/Cold_Storage_of_Agricultural_Products

I. **Course Title : Packaging of Processed Horticultural Produce**

II. **Course Code : PHM 504**

III. **Credit Hours : (1+1)**

IV. **Why this course ?**

Horticulture industry is dominated by market interaction in terms processing and their packaging. Much of the total cost of produce is determined by nature of packaging and packaging material used. Packaging cost sometimes exceed the raw material cost, depending on the nature of the produce, time and period. This course helps in understanding the packaging interaction with produce, environment and time. And it also helps to take informed decision on package requirement for horticulture produce.

V. Aim of the course

To acquaint with the different and packaging systems for processed horticultural produce.

The course is organized as follows:

No	Blocks	Units
1	Packaging principles and functions	Functions of packaging Basic principles of packaging materials Manufacture of packaging materials Types of packaging materials Testing of packaging

VI. Theory

Block 1: Packaging principles and functions

Unit I: Functions of packaging; Type of packaging materials; Selection of packaging material for different foods; Selective properties of packaging film; Methods of packaging and packaging equipment.

Unit II: Mechanical strength of different packaging materials; Printing of packages; Barcodes and other marking; Interactions between packaging material and foods; Environmental and cost consideration in selecting packaging materials.

Unit III: Manufacture of packaging materials; Potential of biocomposite materials for food packaging; Packaging regulations; Packaging and food preservation; Disposal of packaging materials.

Unit IV: Metal cans: types, fabrication, lacquering and tin quality. Double seaming technology – defects and causes. Glass containers – types; testing quality – thermal shock resistance, thermal shock breakage, impact breakage.

Unit V: Testing of packaging; Rigid and semi rigid containers; Flexible containers; Sealing

Equipment. Labeling; Aseptic and shrink packaging; Secondary and transport packaging. Different packaging systems for dehydrated foods, frozen foods, dairy foods, fresh fruits and vegetables.

VII. Practical

- Testing of packaging material: compression strength/drop test/thermal shock test/ seam evaluation/ seam defects;
- Determination of shelf-life of processed products in different types of packages;
- Study of packaging machines – vacuum packaging machine, shrink wrapping machine, double seamer, etc.;
- Visit to packaging units.

VIII. Teaching Methods/ Activities

- Lectures
- Assignments (Reading/ Writing)
- Exposure visits
- Student presentations
- Group Discussions

IX. Learning outcome

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

- Importance of packaging for processed horticultural produce
- Different methods of packaging, methods and their applications in food industry.

X. Suggested Reading

Ahvenainen R. 2001. *Novel Food Packaging Techniques*.CRC

Ahvenainen R. 2003. *Novel Food Packaging Techniques*, CRC Press, ISBN 0849317894. Coles R, McDowell D and Kirwan MJ. (Eds.) 2003. *Food Packaging Technology*, Blackwell

Publishing, ISBN 1841272213.

Joseph H Hotchkiss. 1987. *Food and Packaging Interactions*, (ACS symposium series -365, April 5-10, 1987. American Chemical Society, Washington DC. 1988)

Mahadevaiah M and Gowramma RV. 1996. *Food packaging materials*. Tata McGraw Hill. Painy FA. 1992. A handbook of food packaging. Blackie Academic.

Robertson G. L. Ed. 2010. *Food packaging and shelf life: a practical guide CRC Press*, ISBN 9781420078442.

Thompson AK. 2010. *Controlled Atmosphere Storage of Fruits and Vegetables*, CABI Publishing; 2nd revised edition.

Wilson CL. (Ed.). 2007. *Intelligent and active packaging for fruits and vegetables*, CRC Press, ISBN 9780849391668.

I. Course Title : Principles and Methods of Fruit and Vegetable Preservation

II. Course Code : PHM 505

III. Credit Hours : (2+1)

IV. Why this course ?

The fruits and vegetables are comparative higher value than cereals and more perishables. Losses in the fruits and vegetables are high and chances to reduce the waste and enhancing the employability through post-harvest processing are more. The processing includes pre-processing of fruits and vegetables before these are fit to final conversation into processed foods. The food preservation and processing industry has now become of a necessity than being a luxury. It has an important role in conservation and better utilization of fruits and vegetables. In order to avoid the glut and utilize the surplus during the season, it is necessary to employ

modern methods to extend storage life for better distribution and also processing techniques to preserve them for utilization in the off season on both large scale and small scale. Hence this customized course.

V. Aim of the course

Understanding spoilage, underlying principles and methods of processing of fruits and vegetables.

VI. Learning outcome

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

- Understand Principles and different methods of preservation
- Principal spoilage organisms, food poisoning and their control measures
- Canning of fruits and vegetables
- Processing equipments and layout of processing industry

VII. Theory

Block 1: Principles and Methods of Fruit and Vegetable Processing

Unit I: Introduction, Historical development in food processing, type of food and causes for food spoilage. Basic principles of fruits and vegetables processing;

Unit II: Thermal processing, pH classification of foods, heat resistance of microorganism; Heat resistance of enzymes in foods, Spoilage of thermal processed food; Containers – canning, rigid tin plates and cans, aluminium cans, glass containers – types; flexible packaging materials, Composite can, specification, corrosion of cans, heat penetration into containers and methods for determination of process time.

Unit III: Effects of low temperature on fresh commodities and prepared product. Freezing preservation, freezing points of foods, slow and quick freezing, Cryogenic freezing and frozen food storage. Drying and dehydration, sun drying solar dehydration, mechanical drying types of driers, osmotic dehydration.

Unit IV: Food fermentation – alcoholic, acetic and lactic fermentation. Pickling and curing; Effect of salt on food preservation, types of salt cured products. Traditional and new products; chemical preservation, SO2, benzoic acid, sorbic acid, antioxidants and antibiotics, newer preservatives. Preservation by controlling water activity – high sugar products, intermediate moisture food, food concentration.

Unit V: Food irradiation, principles, types and sources of radiation, mode of action of ionizing radiation; radiation effect on food constituents and regulation.

VII. Practical

- List and cost of equipment, utensils, and additives required for small scale processing industry;
- Chemical analysis for nutritive value of fresh and processed fruits and vegetables;

- Preparation and preservation of fruit based beverages and blended products from fruits and vegetables;
- Evaluation of pectin grade; preparation and quality evaluation of fruit jam;
- Preparation of papain;
- Blanching and its effects on enzyme;
- Preparation of dehydrated vegetables;
- Study of different types of spoilages in fresh as well as processed horticultural produce;
- Study of biochemical changes and enzymes associated with spoilage;
- Sensory evaluation of fresh and processed fruits and vegetables;
- Visit to processing units.

VIII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Exposure visits
- Student presentation
- Group Work

IX. Suggested Reading

Barret DM, Somogyi LP and Ramaswamy H. Eds. 2005. *Processing Fruits: Science and Technology* (2nd Edition), CRC Press, ISBN 9780849314780.

FAO. 2007. *Handling and Preservation of Fruits and Vegetables by Combined Methods for Rural Areas- Technical Manual*. FAO Agricultural Services Bulletin 149.

Fellows PJ. 2009. Food Processing Technology: Principles and Practice (3rd Edition), Woodhead Publishing, ISBN 9781845692162.

Lal G, Siddappa GS and Tandon GL. 1998. Preservation of Fruits and Vegetables. ICAR, ISBN 9788171640904.

Ramaswamy H and Marcotte M. 2006. *Food Processing: Principles andApplications*. Taylor & Francis.

Salunkhe DK and Kadam SS. 1995. Handbook of Fruit Science and Technology:Production, Composition and Processing. Marcel Dekker.

Srivastava RP and Kumar S. 2014. *Fruit and Vegetable Preservation: Principles and Practices*

(3rd Edition), CBS Publishing, ISBN 9788123924373.

Verma LR and Joshi VK. 2000. *Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management*. Indus Publishing Company, New Delhi, India. ISBN 8173871086.

Websites

http://agriinfo.in/default.aspx?page=topic&superid=2&topicid=2065

http://www.fao.org/docrep/x0209e/x0209e02.htm

http://www.cstaricalcutta.gov.in/images/CTS%20Fruits_and_Vegetables%20NSQF.pdf

I. **Course Title : Laboratory Techniques in Postharvest Horticulture**

II. **Course Code : PHM 506**

III. **Credit Hours : (1+2)**

IV. **Why this course ?**

To familiarize with the conventional analysis of raw and processed food products of all commodity technologies used for routine quality control in food industry, and their role on nutritional labeling. To develop an understanding and methodologies of instrumental techniques in food analysis used for objective methods of food quality parameters.

V. Aim of the course

To familiarise with advances in instrumentation and Postharvest management

VI. Theory

Block 1: Laboratory Techniques in Postharvest Management

Unit I: Rheological techniques and instrumentation used in food industry. Analysis of food additives like food colour, antioxidants, emulsifier, etc.

Unit II: Analysis of pesticide residues, metallic contaminants, aflatoxin. Analysis of food flavours.

Unit III: Quality analysis of processed fruits and vegetables, coffee, tea and spices. Identification and enumeration of microbial contaminants.

Unit IV: Principles of chromatography (GC, GCMS, HPLC, LCMS), spectrophotometry (Atomic absorption spectrophotometer, ICAP spectrophotometer), ICP-MS, ICPOES, NMR, ESR, amino acid analyser, flame photometry, electrophoresis.

Unit V: Colour measurement in foods, IRGA, Radio-isotopic techniques. Non destructive quality evaluation (NDQE)- E-nose, E-tongue, machine vision. electrophoresis.

VII. Practical

- Sample preparation for quality analysis. Energy calculation, sample calculations;
- Texture analysis, Rheology of different foods;
- Instrumental colour analysis;
- Sensory evaluation and microbiological examinations of fresh and processed products;

- Estimation of tannin/ phytic acid by spectrometric method;
- Moisture and fat analysis by NIR spectroscopy;
- Separation and identification of sugars in fruit juices;
- Separation and identification of carotenoids by column chromatography;
- Estimation of respiration in fruits and vegetables;
- Flavour profile in essential oils using GC;
- Identification and determination of organic acids by HPLC;
- Capsaicin content and Scoville Heat Units in chillies;
- Heavy metal analysis using atomic absorption spectrometry;
- Residue analysis.

VIII. Teaching Methods/ Activities

- Lectures
- Assignments (Reading/ Writing)
- Exposure visits
- Student presentations

IX. Learning outcome

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

- Techniques and instrumentation used in food industry
- Analysis of pesticide residues
- Quality analysis of processed fruits and vegetables
- Principles of chromatography and Spectrophotometry
- Non-destructive quality evaluation

X. Suggested Reading

Lundanes E., Reubsaet L and Greibrokk T. 2013. *Chromatography: Basic Principles, Sample Preparations and Related Methods*, ISBN-13: 978-3527336203, Wiley VCH

Mark F Vitha. 2016. *Chromatography: Principles and Instrumentation*. John Wiley & Sons, ISBN 9781119270881

Suzanne NS. 2010. *Introduction to Food Analysis*, ISBN 978-1-4419-1478-1, Springer. Ranganna S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*,

Tata McGraw-Hill ISBN 9780074518519.

Semih Otles (Ed). 2016. *Methods of Analysis of Food Components and Additives* (*Chemical and Functional Properties of Food Components*) CRC Press, ISBN-13: 978-1138199149,

I. Course Title : Processing of Horticultural Produce

II. Course Code : PHM 507

III. Credit Hours : (2+2)

IV. Why this course ?

Postharvest system deals with ensuring the delivery of a crop from the time and place of harvest to the time and place of consumption, with minimum loss, maximum efficiency and returns to all concerned including grower, processors and consumer. The term 'system' represents a dynamic, complex aggregate of locally interconnected functions or operations within a particular sphere of activity. While, the term pipeline of operations refers to the functional succession of various operations but tends to ignore their complex interactions. Primary processing processing operations include washing/ cleaning,sorting, grading, dehulling, pounding, grinding, packaging, soaking, winnowing, drying, sieving,

whitening and milling and secondary operations include mixing, cooking, drying, frying, moulding, cutting, extrusion product preparation.

V. Aim of the course

This course gives an overview of status of fruit and vegetable processing in the country, objectives and importance of preservation, important constraints and different unit operations processing industry which helps in expansion of industry and scope for further growth in this sector.

This course is organized as follows:

No	Blocks	Units	
1	Importance and Thermal processes	I	Scope and Importance
		1.	Thermal processes
		2.	Evaporation
2.	Processing equipment and enzyme facilities kinetics	I	Processing equipment and
		II	Enzyme kinetics

VI. Theory

Block 1: Importance and Thermal processes

Unit I: Processing unit- layout and establishment, processing tools. Quality requirements of raw materials for processing, preparation of raw material, primary processing: grading, sorting, cleaning, washing, peeling, slicing and blanching; minimal processing.

Unit II: Preparation of various processed products from fruits and vegetables, flowers; role of sugar and pectin in processed products. Freezing of fruits and vegetables. Containers, equipment and technologies in canning.

Unit III: Juice extractions, clarification and preservation, recent advances in juice processing technology, application of membrane technology in processing of juices, preparation of fruit beverages and juice concentrate. Sensory evaluation.

Block 2: Processing equipment and enzyme kinetics

Unit I: Dehydration of fruits and vegetables using various drying technologies and equipment, solar drying and dehydration, packaging technique for processed products.

Unit II: Quality assurance and storage system for processed products. Nutritive value of raw and processed products, plant sanitation and waste disposal. Types of horticultural and vegetables wastes and their uses, utilization of by- products from fruits and vegetables processing industries.

VII. Practical

1. Handling of harvesting equipments;
2. Determination of physical and thermal properties of horticultural commodities;
3. Thermal process calculations;
4. Particle size analysis, Storage structure design;
5. Numerical problems in freezing, drying, conveying and calculations pertaining to texture and Rheology;
6. Handling of heating equipment, pulper, juice extractor, deaerator, juice filters;
7. Processing industries waste treatment;

8. Working of a canning unit;
9. Visit to commercial processing units and storage units.

VIII. Teaching Methods/ Activities

1. Lectures
2. Assignments (Reading/ Writing)
3. Exposure visits
4. Student presentations

IX. Learning outcome

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

1. Unit operations of processing
2. Planning for domestic as well as commercial storage and processing facilities
3. Kinetics of growth and enzyme reaction

X. Suggested Reading

Karel M and Lund DB. 2003. *Physical Principles of Food Preservation* (2nd Edition), CRC Press, ISBN 9780824740634.

Paul Singh R and Heldman DR. 2009. *Introduction to Food Engineering* (4th Edition), Academic Press, ISBN 9780123709004.

Rao DG. 2010. *Fundamentals of Food Engineering*, PHI Learning Pvt. Ltd., ISBN 9788120338715.

Ratti C. 2008. *Advances in Food Dehydration*, CRC Press, ISBN 9781420052527.

Toledo RT. 2007. *Fundamentals of Food Process Engineering* (3rd Edition), Springer, ISBN 9780387290195.

Smith PG. 2011. *Introduction to Food Process Engineering*, Springer, ISBN 9781441976611.

I. Course Title : Quality Assurance, Safety and Sensory Evaluation of Fresh and Processed Horticultural Produce

II. Course Code : PHM 508

III. Credit Hours : (2+1)

IV. Why this course ?

The quality of fresh horticultural commodities is a combination of characteristics, attributes, and properties that give the commodity value for food (fruits and vegetables) and enjoyment (ornamentals). Producers are concerned that their commodities have good appearance and few visual defects, but for them a useful cultivar must score high on yield, disease resistance, ease of harvest, and shipping quality. To receivers and market distributors, appearance quality is most important; they are also keenly interested in firmness and long storage life. Although consumers buy on the basis of appearance and feel, their satisfaction and repeat purchases are dependent upon good edible quality. Assurance of safety of the products sold is extremely important to the consumers. Hence this customized course.

V. Aim of the course

To understand the quality and safety management system and the process of sensory analysis for horticultural products

This course is organized as follows:

No	Blocks	Units
1	Quality Assurance	I Concept of quality
		II Food laws and regulations
2	Safety	I Food safety
		II Quality management
3.	Sensory Evaluation	I Introduction to sensory evaluation
		II Methods of sensory evaluation

VI. Theory

Block 1: Quality Assurance

Unit I: Concept of quality: Quality attributes- physical, chemical, nutritional, microbial, and sensory; their measurement and evaluation. Concepts of quality management: Objectives, importance and functions of quality control; Quality management systems in India; Sampling procedures and plans.

Unit II: Food laws and regulations in India, Quality management standards, ISO,BIS, PFA, AGMARK and QMS standards, quality system components and their requirements.

Block 2: Safety

Unit I: Food safety and standards act (FSSA,2006); Strategies for compliance with international agri-food standards; Export specification and

guidelines by APEDA. Hazard analysis and critical control points (HACCP), design and implementation of an HACCP system, steps in the risk management process. Traceability in food supply chains.

Unit II: Organic Certification, GAP, GMP, TQM. Indian and International quality systems and standard like, Codex Alimentarius, ISO, etc. Consumer perception of safety; Ethics in food safety.

Block 3: Sensory Evaluation

Unit I: Introduction to sensory analysis; general testing conditions, Requirements of sensory laboratory; organizing sensory evaluation programme. Selection of sensory panellists; Factors influencing sensory measurements; Sensory quality parameters -Size and shape, texture, aroma, taste, colour and gloss; Detection, threshold and dilution tests. Different tests for sensory evaluation– discrimination, descriptive, affective; Flavour profile and tests; Ranking tests.

Unit II: Methods of sensory evaluation of different food products. Designing of experiments. Handling and interpretation of Data. Role of sensory evaluation in product optimization. Relationship between objective and subjective methods.Sensory analysis for consumer evaluation. Computer-aided sensory evaluation of food and beverage.

VII. Practical

- Analysis for TSS, pH, acidity, sugars, pectic substances, minerals, vitamin C, carotene, alcohol, benzoic acid and SO_2 contents, yeast and microbial examination in processed products;
- Demonstration of measurement of vacuum/ pressure, head space, filled weight, drained weight, cut-out analysis and chemical additives;
- Moisture content, rehydration ratio and enzymatic/ non-enzymatic browning in

dehydrated products;

- Analysis of spices for quality parameters. Evaluation of processed products according to FSSAI specification;
- Selection and training of sensory panel;
- Identification of basic taste, odour, texture and colour;
- Detection and threshold tests; Ranking tests for taste, aroma, colour and texture; Sensory evaluation of various horticultural processed products using different scales, score cards and tests, Hedonic testing;
- Estimation of color and texture; optimising a product by sensory analysis;
- Studying relationship between objective and subjective methods.

VIII. Teaching Methods/ Activities

- Lectures
- Assignments (Reading/ Writing)
- Exposure visits
- Student presentation

IX. Learning outcome

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

- Concepts of quality management
- Food laws and regulation in India

- Export specification and guidelines by APEDA
- Consumer perception of safety and Ethics in food safety

x. Suggested Reading

Amerine MA, Pangborn RM and Rosslos EB. 1965. Principles of Sensory Evaluation of Food.

Academic Press.

Curtis PA. 2005. *Guide to Food Laws and Regulations*, Wiley-Blackwell, ISBN 9780813819464.DGHS *Manual 8: Manual of Methods of Analysis of Foods-Food Additives*. Curtis PA. 2005. *Guide to Food Laws and Regulations*, Wiley-Blackwell, ISBN 9780813819464. Early R. 1995. *Guide to Quality Management Systems for the Food Industry*, Springer, ISBN

9781461358879.

Kemp SE, Hollowood T and Hort J. 2009. *Sensory Evaluation: A Practical Handbook*, Wiley- Blackwell Publisher, ISBN 9781405162104.

Krammer A and Twigg BA. 1973. Quality Control in Food Industry.Vol.I, II.AVI Publ.

Lawless, Harry T, Heymann and Hildegarde. 2010. Sensory Evaluation of Food: Principles and Practices, Springer, ISBN 9781441964885.

Ranganna S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw-Hill ISBN 9780074518519.

Ranganna S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw-Hill, ISBN 9780074518519.

The Food Safety and Standards Act, 2006 along with Rules & Regulations 2011, Commercial Law Publishers (India) Pvt. Ltd.

Websites

https://en.wikipedia.org/wiki/Sensory_analysis

https://link.springer.com/chapter/10.1007/978-1-4757-5112-3_5

https://www.foodqualityandsafety.com/

I. **Course Title : Functional Foods from Horticultural Produce**

II. **Course Code : PHM 509**

III. **Credit Hours : (2+0)**

IV. **Why this course ?**

Functional foods are foods that have a potentially positive effect on health beyond basic nutrition. This course examines the rapidly growing field of functional foods in the prevention and management of chronic and infectious diseases. It attempts to provide a unified and systematic account of functional foods by illustrating the connections among the different disciplines needed to understand foods and nutrients, mainly: food science, nutrition, pharmacology, toxicology and manufacturing technology. Advances within and among all these fields are critical for the successful development and application of functional foods

V. Aim of the course

To familiarise with functional foods from horticultural produce This course is organized as follows:

No	Blocks	Units
1	Functional food and importance	I Introduction, Sources and classification
2.	Bioactive Compounds	1. Functional Ingredients I Introduction and classes of bioactive compounds II Mechanism of Neuroprotection

3.	Neutraceuticals	1	Introduction, classification, role and health benefits

VI. Theory

Block 1: Functional food and importance

Unit I: Functional foods- Introduction, definition, history; Importance, relevance and need of functional foods. Sources and classification of functional foods.Importance of horticultural produce as functional foods. Functional foods derived from fruits, vegetables, medicinal and aromatics.

Unit II: Functional ingredients and their properties. Therapeutic potential and effects of horticultural produce; Herbs, herbal teas, oils, etc. in the prevention and treatment of various diseases. Effect of preservation and processing on functional properties of horticulture produce.

Block 2: Bioactive Compounds

Unit I: Introduction, Classes of bioactive compounds present in fruits and vegetables. Polyphenols: Phenolic acid, Stilbenes, Flavonoids, Lignin, Coumarin, Tannin, etc. –their chemistry, source, bioavailability, interaction in food systems; changes during storage and processing. Alkaloids; Nitrogen Containing Compounds; Sulphur compounds; phytosterols; carotenoids; dietary fibres, etc.– their chemistry, source, bioavailability, interaction in food systems; changes during storage and processing.

Unit II: Mechanism of neuroprotection by bioactive compounds. Techniques of Extraction, purification and concentration of bioactive compounds from fruits and vegetables.Bioactive compound and health benefits Incorporation of bioactive compounds in foods.

Block 3: Neutraceuticals

Unit I: Nutraceuticals- Introduction, classification of nutraceuticals, dietary supplements, fortified foods, functional foods and phytonutraceuticals. Role of medicinal and aromatic plants in nutraceutical industry. Health benefits of phytoneutraceuticals.

VII. Teaching Methods/ Activities

1. Lectures
2. Assignment (Reading/ Writing)
3. Exposure visits
4. Student presentation

VIII. Learning outcome

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

- Importance of functional foods
- Functional ingredients and their properties
- Classes of bioactive compounds present in fruits and vegetables
- Mechanism of neuroprotection by bioactive compounds
- Importance of Nutraceuticals

IX. Suggested Reading

Rosa LA, Alvarez-Parrilla E and Gonzalez-Aguilar GA. 2009. *Fruit and Vegetable Phytochemicals: Chemistry, Nutritional Value and Stability*, Wiley-Blackwell, ISBN 9780813803203.

Senrawat R, Khan KA, Goyal MR and Paul PK. 2018. *Technological Interventions in the Processing of Fruits and Vegetables*, Apple Academic Press, ISBN 9781771885867.

Vattem DA. 2016. *Functional Foods, Nutraceuticals and Natural Products: Concepts and Applications*. DEStech Publications, Inc, ISBN 978 1 60595 101 0.

Watson RR and Preedy V. 2009. *Bioactive Foods in Promoting Health: Fruits and Vegetables*

(1st Edition), Academic Press, ISBN 9780123746283

I. Course Title : Marketing and Entrepreneurship in Post Harvest Horticulture

II. Course Code : PHM 510

III. Credit Hours : (1+1)

IV. Why this course ?

To develop marketing strategies and equip individuals to start their own food service.To develop Techniques for the development of entrepreneurial skills, positive self image and locus of control.

V. Aim of the course

To understand the market channel and appraise entrepreneurship opportunity in postharvest operations.

This course is organized as follows:

No	Blocks	Units
1	Marketing and entrepreneurship	I Entrepreneurship in processing industry II Business Plan
		1. MSME Enterprise 2. Marketing 3. Institutional supports

VI. Theory

Unit I: Entrepreneurship – Concept, need for entrepreneurship – Types of entrepreneurs -entrepreneurial opportunities in horticultural processing sector-Government schemes and incentives for promotion of entrepreneurship in processing sector.

Unit II: Writing Business Plan- Business Plan Format for Small and micro Enterprises-Generation, incubation and commercialization of business ideas – Environment scanning and opportunity identification.

Unit III: Steps in establishment of MSME Enterprise – Planning of an enterprise – Formulation and project report-Meaning – Importance Components and preparation.-Government Formalities and Procedures.

Unit IV: Marketing potential of processed products at domestic and international level-Marketing management-Marketing functions, market information and market research-Problems in marketing of processed products-Demand and supply analysis of important processed products-Marketing channels – Marketing strategy (product strategy and pricing

strategy)- Supply chain management – Meaning, importance, advantages, supply chain management of important processed products.

Unit V: Institutional support to Entrepreneurship Role of Directorate of Industries, District Industries, Centres (DICs), Industrial Development Corporation (IDC), State Financial corporation (SFCs), Commercial banks Small Scale Industries Development Corporations (SSIDCs), Khadi and village Industries Commission (KVIC), National Small Industries Corporation (NSIC), Small Industries Development Bank of India (SIDBI).

VII. Practical

- Consumer Behaviour towards Processed Foods;
- An Empirical Test-Carrying out the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of successful Enterprises;
- Constraints in setting up of horti based industries;
- Field visits to study any one of the Local Financial Institutions to study the MSME Policies;
- Preparation of business plan and proposal writing-Project evaluation techniques;
- Discounted and undiscounted techniques;
- Case studies of successful entrepreneurs.

VIII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/Writing)
- Exposure visits
- Student presentation

IX. Learning outcome

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

- Concept of entrepreneurship
- Writing Business Plan
- Steps in establishment of MSME Enterprise
- Marketing management
- Institutional support to Entrepreneurship

x. Suggested Reading

Adhikary MM. 2014. *Enterprise and Entrepreneurship for Agri-Business Management and Planning*. Daya Publishing House. New Delhi

Bhaskaran S. 2014. *Entrepreneurship Development and Management*. Aman Publishing House, Meerut.

Choudhury M and Barua N. 2014. *Marketing of Processed Fruit and Vegetable*. Daya Publishing House. New Delhi.

Gaur SC. 2012. *Handbook of Agro Food Processing and Marketing*. Agrobios. Jodhpur Kadam MM and Bishe RN. 2018. *Textbook on Agricultural Entrepreneurship*. Narendra

publishing house. New Delhi.

Sudheer KP and Indira V. 2018. *Entrepreneurship and Skill Development in Horticultural Processing*. New India Publishing Agency. New Delhi.

Sudheer KP and Indira V. 2018. *Entrepreneurship Development in Food Processing*. New India Publishing Agency. New Delhi