Agriculture and Allied Science

Restructured and Revised Syllabi of Post-graduate Programmes

Volume 5 - Horticultural Science

- Fruit Science
- Vegetable Science
- Floriculture and Landscaping
- Plantation, Spices, Medicinal and Aromatic Crops
- Postharvest Management

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Compiled By

Dean & Director of Instruction Co-Ordination Committee of SAU's 2022-23

Restructured and Revised Syllabus

Horticultural Sciences

M.Sc. & Ph. D. (Horticulture)

in

Fruit Science

Submitted by

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CONTENT

1. Preamble

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

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

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

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

2. Committee of Broad Subject Coordinators and Discipline Coordinators for finalizing the PG Degrees Syllabi in the Maharashtra SAUs as per the ICAR-NCG-BSMA recommendations.

Discipline	Degree Programme		Broad Subject Coordinator (Chairman of Fruit Science Discipline)	Discipline Coordinator (Secretary of Fruit Science Discipline)	Co-Opted Members
Fruit Science	M.Sc.	Ph.D.	Dr. P. K. Nagre Associate Dean, College of Agriculture, Dr. PDKV, Akola E-mail: pk.nagre1@gmail.com Mobile: 9028296172	Dr. G. M.Waghmare Head (FS), VNMKV, Parbhani	Dr. K.V. Malshe Member & Associate Professor (FS) Dr. BSKKV, Dapoli
				Dr. S. G. Bharad Head (FS), Dr. PDKV, Akola	Dr. S.S. Dhumal Member & Associate Professor (FS) MPKV, Rahuri

For finalization of PG Fruit Science syllabus total eight meetings were held. Out of which seven held online mode (on dated 30.03.2022, 01.04.2022, 06.04.2022, 10.04.2022, 11.04.2022, 25.07.2022 and 11.08.2022) and one physical meeting were held at Department of Horticulture, VNMKV, Parbhani on dated 11.05.2022.

Dr. G. M.Waghmare
Discipline Coordinator
Head (FS),
VNMKV, Parbhani

Dr. S. G. Bharad
Discipline Coordinator
Head (FS),
Dr. PDKV, Akola

Dr. P. K. Nagre
Broad Subject Coordinator
&
Associate Dean, College of Agriculture, Dr. PDKV, Akola.

Implementation of New Curriculum

The universities offering PG programmes in Horticultural sciences (Fruit Science) need to be supported for establishing specialized laboratories equipped with state-of-the-art equipment's for conducting practical classes. A one-time catch-up grant should be awarded to each SAU, offering PG programmes in Fruit Science to meet the expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. To execute the new PG programmes in Fruit Science in an effective manner, special funds from ICAR would be required for the outsourcing of faculty from Indian/Foreign Universities for some initial years.

Expected Outcome

- Revamping of post graduate programme in whole of Fruit Science throughout the country.
- Imparting quality education.
- Development of technical manpower to cater the need of governments, corporate sector and research organization in India and abroad. Exposure to the faculty in the latest technical knows.

3. Organization of Course Contents & Credit Requirements

3.1. Minimum Residential Requirement:

M. Sc.: 4 Semesters

Ph. D.: 6 Semesters

3.2. Name of Department / Division

Fruit Science

3.3. Nomenclature of Degree Programme

M.Sc. (Hort.) in Fruit Science

Ph.D. (Hort.) in Fruit Science

3.4. Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars for Doctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

3.5. Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.
- Lecture schedule and practical schedule has also be given at the end of each course to facilitate the teacher to complete the course in an effective manner.

3.6. Eligibility of Admission

Master's Degree Programme

B.Sc. Horticulture/ B.Sc. (Hons.) Horticulture.B.Sc. Agri. / B.Sc. (Hons.) Agriculture / B.Sc. Forestry/ B.Sc. (Hons.) Forestry, or equivalent degree with four years duration of agriculture and related Universities and having the common entrance test in Horticulture conducted by competent authority.

Doctoral Degree Programme

Master Degree in the concerned Department/ Discipline (M.Sc. (Hort.) in Fruit Science) and having appearing the Common Entrance Test conducted by competent authority.

4. Credit Requirements

Course Details	Masters' Degree	Doctoral Degree
Major Courses	20	12
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

5. M.Sc. (Hort.) Fruit Science Course Structure

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 PGS Non Credit courses		**05**
FSC 591	**Masters Seminar**	**0+1**
FSC 599	**Masters Research**	**0+30**
	Total Credits	**70**
Major 20 + Minor 08+ Supporting 06 + NCCC 05 + Seminar 01+ Research 30 = 70		

***Compulsory among major courses.**

Common PGS Courses: (Non Credit)

Course code	Course Title	Credit Hours
PGS-501	Library and Information Services	0+1
PGS-502	Technical Writing and Communications Skills	0+1
PGS-503	Intellectual Property and its Management in Agriculture	1+0
PGS-504	Basic Concepts in Laboratory Techniques	0+1
PGS-505	Agricultural Research, Research Ethics and	1+0
PGS-506	Disaster Management	1+0

Minor Disciplines: Suggestive list of discipline for minor courses

1. Genetics and Plant Breeding
2. Plant Physiology
3. Biochemistry
4. Agronomy
5. Soil Science
6. Vegetable science
7. Agricultural Statistics
8. Biotechnology
9. Floriculture and Landscaping
10. Plantation, Spices, Medicinal and Aromatic Crops
11. Post-harvest Management

Note: These are the minor disciplines for M.Sc. Students; however some suggestive minor courses included in semester wise layout.

Minor Courses- Suggestive list of minor courses

Course Code	Course title	Credit hours
BIOCHEM 501	Basic Biochemistry	3+1
PP 501	Principles of Plant Physiology-I: Plant Water Relations and Mineral Nutrition	2+1
GPB 502	Principles of Plant Breeding	2+1
GPB 514	Breeding of Fruit Crops	2+1
PP 505	Hormonal Regulation of Plant Growth and Development	2+1
PP 509	Physiology of Horticultural Crops	2+0
PP 512	Crop Growth Regulation and Management	2+0
AGRON 503	Principles and Practices of Weed Management	2+1
SOIL 502	Soil fertility and Fertilizer use	2+1
SOIL 510	Analytical Technique and Instrumental Methods in Soil and Plant Analysis	0+2

Supporting/Optional Courses:

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Statistic
2. Agronomy
3. Soil Science
4. Biochemistry
5. Organic Farming
6. Forestry
7. Plant Pathology
8. Plant Physiology
9. Entomology
10. Computer Science and Information Technology

Supporting Courses: Suggestive list of Supporting Courses

Course Code	Course Title	Credit Hours
STAT 502	Statistical Methods for Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 505	Techniques in Biochemistry	2+2
AGRON 512	Dry land farming and watershed management	2+1=3

Compulsory Non Credit Deficiency Courses:

Those who are non B.Sc. (Agri)/ B.Sc. (Hons.) Agriculture/ B.Sc. (Hort)/ B.Sc. (Hons.) Horticulture or equivalent degree with four years duration of Agriculture related University

Course No.	Course Title	Credit Hours
FSC- 411	Fundamentals of Horticulture	2+1
FSC – 422	Plant propagation and nursery Management	1+1
FSC - 433	Tropical and Subtropical Fruits	2+1
FSC - 434	Temperate Fruit Crops	1+1
FSC - 435	Weed Management in Horticultural Crops	1+1
FSC - 446	Breeding of Fruit and Plantation Crops	2+1
FSC - 447	Dry Land Horticulture	1+1
FSC - 458	Plantation Crops	2+1
FSC - 469	Orchard and Estate Management	1+1

Note: Students from Non Agri / Hort will be required to complete Non-Credit Deficiency Courses (6 -10 credit) from the above courses as decided by the Student Advisory Committee.

6. Ph. D. (Hort.) in Fruit Science Course Structure

Course Code	Course Title	Credit Hours
	Major Courses (12 Credits)	
FSC 601*	Innovative Approaches in Fruit Breeding	3+0
FSC 602*	Modern Trends in Fruit Production	3+0
FSC 603	Recent Developments in Growth Regulation	3+0
FSC 604	Advanced Laboratory Techniques	1+2
FSC 605	Arid and Dry Land Fruit Production	2+0
FSC 606	Abiotic Stress Management in Fruit Crops	2+1
FSC 607	Biodiversity and Conservation of Fruit Crops	2+1
FSC 608	Smart Fruit Production	2+0
Minor Courses		**06**
Supporting Courses		**05**
Common compulsory courses		**--**
FSC 691	**Seminar-I**	**0+1**
FSC 692	**Seminar-II**	**0+1**
FSC 699	**Research**	**0+75**
	Total Credits	**100**

***Compulsory among major courses**

Minor Disciplines: Suggestive list of minor discipline

1. Genetics and Plant Breeding
2. Plant Physiology
3. Biochemistry
4. Agronomy
5. Soil Science
6. Agricultural Statistics
7. Vegetable science
8. Biotechnology
9. Floriculture and Landscaping
10. Plantation, Spices, Medicinal and Aromatic Crops
11. Post-harvest Management

Note: These are the minor disciplines for Ph.D. Students; however some suggestive minor courses included in semester wise layout.

Minor Courses: Suggestive list of Minor Courses

Course Code	Course Title	Credit Hours
GPB 605	Genomics in Plant Breeding	3+0
PP 602	Signal Perceptions and Transduction and Regulation of Physiological Processes	2+0
PP 607	Physiological and Molecular Aspects of Source-sink Capacity for Enhancing Yield	3+0
MBB 601	Plant Molecular Biology	3+0
AGRON 605	Integrated farming systems for sustainable Agriculture	2+0
AGM 601	Climate change and sustainable development	2+1

Supporting Discipline: Suggestive list of supporting Discipline

1. Agronomy
2. Soil Science
3. Agricultural Economics and Agricultural Statistics
4. Biochemistry and Microbiology
5. Genetics and Plant Breeding (GPB)
6. Plant Physiology
7. Molecular Biology and Biotechnology

Supporting Courses: Suggestive list of supporting courses

Course Code	Course Title	Credit Hours
AGRON 604	Recent trends in Weed Management	2+0
STAT 601	Advanced Data Analytics	1+2
STAT 604	Advanced Statistical Methods	2+1
MBB 602	Plant Genome Engineering	3+0
SOIL 603	Physical chemistry of soil	2+0
MICRO 601	Improvement in fermentation Technology	2+1

Note: Student Advisory committee may select the supporting courses from above listed disciplines however, some courses are suggested.

7. COURSE CONTENT OF MASTER DEGREE

Course Title: Tropical Fruit Production

Course Code: FSC 501

Credit Hours: (2+1)

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.

Crops

Mango, Banana, Guava, Papaya, Jamun, Jackfruit, Annonas, Aonla, Pineapple, Avocado

PRACTICALS

1. 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
4. Leaf sampling and nutrient analysis
5. Physiological disorders-malady diagnosis
6. Physico-chemical analysis of fruit quality attributes
7. Field/ Exposure visits to tropical orchards
8. Project preparation for establishing commercial orchards.

TEACHING SCHEDULE

THEORY

Block / Lec. No.	**Topic**	**Weightage (%)**
Block-1 Block-2 Block-3	Importance and Background: Importance, origin and distribution, major species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements. 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. 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.	
Lecture No.	Topic	Weightage (%)
1-5	Mango	15
6-9	Banana	15
10-13	Guava	10
14-17	Papaya	10
18-19	Jamun	10
20-21	Jackfruit	10
22-25	Annonas	15
26-28	Aonla	5
29-30	Pineapple	5
31-32	Avocado	5

Practical:

Practical's No.	Topic
1-2	Distinguished features of tropical fruit species, cultivars and rootstocks
3-5	Demonstration of planting systems, training and pruning
6-7	Hands on practices on pollination and crop regulation
8-10	Leaf sampling and nutrient analysis
11	Physiological disorders-malady diagnosis
12-14	Physico-chemical analysis of fruit quality attributes
15	Field/ Exposure visits to tropical orchards
16	Project preparation for establishing commercial orchards.

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.

Course Title: Subtropical and Temperate Fruit Production

Course Code: FSC 502

Credit Hours: (2+1)

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, Per-simmon, Kiwifruit, Nuts- Walnut, Almond, Pecan, etc

PRACTICALS

1. 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
4. Leaf sampling and nutrient analysis
5. Physiological disorders-malady diagnosis
6. Physico-chemical analysis of fruit quality attributes
7. Field/ Exposure visits to subtropical and temperate orchards
8. Project preparation for establishing commercial orchards.

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	**Topic**	**Weightage (%)**
Block-1 Block-2 Block-3	Importance and Background: Origin, distribution and importance, major species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements. 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. 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.	
Lecture No.	Topic	Weightage (%)
1-6	Citrus	15
7-10	Grapes	10
11-13	Litchi	10
14-16	Pomegranate	10
17-21	Apple	10
22-25	Pear, Peach	5
26-27	Plum, Apricot	5
28	Cherries	5
29	Berries	10
30	Persimmon	5
31	Kiwifruit	5
32	Nuts- Walnut, Almond, Pecan, etc	10

Practical:

Practical No.	Topic
1-2	Distinguished features of fruit species, cultivars and rootstocks
3-5	Demonstration of planting systems, training and pruning
6-7	Hands on practices on pollination and crop regulation
8-10	Leaf sampling and nutrient analysis
11	Physiological disorders-malady diagnosis
12-14	Physico-chemical analysis of fruit quality attributes
15	Field/ Exposure visits to subtropical and temperate orchards
16	Project preparation for establishing commercial orchards

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.

Course Title: Propagation and Nursery Management in Fruit Crops

Course Code: FSC 503

Credit Hours: (2+1)

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.

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 andtransport 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.

PRACTICAL

1. Hands on practices on rooting of dormant and summer cuttings
2. Anatomical studies in rooting of cutting and graft union
3. Hands on practices on various methods of budding and grafting
4. Propagation by layering and stooling
5. Micropropagation- explant preparation, media preparation, culturing – meristem tip culture, axillary bud culture, micro-grafting, hardening
6. Visit to commercial tissue culture laboratories and accredited nurseries

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
1-7	General Concepts and Phenomena: Introduction, understanding cellular basis for propagation, sexual and asexual propagation, apomixis, polyembryony, chimeras.	10
8-11	Factors influencing seed germination of fruit crops, dormancy, hormonal regulation of seed germination and seedling growth.	10
12-14	Seed quality, treatment, packing, storage, certification and testing.	10
15-17	Conventional Asexual Propagation: Cutting– methods, rooting of soft and hardwood cuttings under mist and hotbeds.	10
18-20	Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.	10
21-23	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.	10
24-27	Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in horticultural crops.	10
28-29	Techniques – in-vitro clonal propagation, direct organogenesis, embryogenesis, micrografting, meristem culture, genetic fidelity testing. Hardening, packaging and transport of micro-propagules.	10
30-31	Management Practices and Regulation: Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production.	10
32	Nursery Act, nursery accreditation, import and export of seeds and planting material and quarantine.	10

Practical:

Practicals No.	Topic
1-3	Hands on practices on rooting of dormant and summer cuttings
4-5	Anatomical studies in rooting of cutting and graft union
6-8	Hands on practices on various methods of budding and grafting
9-10	Propagation by layering and stooling
11-14	Micropropagation- explant preparation, media preparation, culturing – meristem tip culture, axillary bud culture, micro-grafting, hardening
15	Visit to commercial tissue culture laboratories and accredited nurseries
16	Nursery project preparation

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.

Course Title: Breeding of Fruit Crops

Course Code: FSC 504

Credit Hours: (2+1)

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. Blossom Biology and Breeding Systems:

Block 2: Reproductive Biology

Unit I: 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, Citrus, Grapes, Guava, Pineapple, Litchi, Kiwifruit, Nuts, Pomegranate, Papaya, Apple, Pear, Plum, Peach, Apricot, Cherries, Strawberry, etc.

Practicals

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

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
1-5 (General)	Importance, Taxonomy and Genetic Resources: Introduction and importance, origin and distribution, taxonomical status – species and cultivars, cytogenetics, genetic resources.	10
6-9	Blossom Biology and Breeding Systems: Blossom biology, breeding systems – spontaneous mutations, polyploidy, incompatibility, sterility, parthenocarpy, apomixis, breeding objectives, ideotypes.	10
10-13	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.	10
14-17	Mango,	10
18-20	Banana,	10
21-23	Citrus	10
24-25	Grapes, Guava	10
26-27	Pineapple, Litchi, Kiwifruit, Nuts	10
28-29	Pomegranate, Papaya,	10
30-31	Apple, Pear, Plum, Peach	5
32	Apricot, Cherries, Strawberry,	5

Practical:

Practicals No.	Topic
1-2	Exercises on bearing habit, floral biology (2);
3	Pollen viability and fertility studies (1);
4-6	Hands on practices in hybridization (3);
7-8	Raising and handling of hybrid progenies (2);
9-10	Induction of mutations and polyploidy (2);
11-12	Evaluation of biometrical traits and quality traits (2);
13-14	Screening for resistance against abiotic stresses (2);
15	Developing breeding programme for specific traits (2);
16	Visit to research stations working on fruit breeding (1).

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

Course Title: Systematics of Fruit Crops
Course Code: FSC 505
Credit Hours: (2+1)

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

Block 2: Botanical Keys and Descriptors

Unit I: Identification and Description: Methods of identification. 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 Biodiversity. 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**.**

PRACTICALS

1. Exercises on identification and pomological description of various fruit species and culti-vars
2. Development of descriptive blanks vis-a-vis UPOV/ DUS test guidelines and Bioversity International
3. Descriptors for developing fruit species and cultivar descriptive databases
4. Visits to major germplasm centres and field genebank.

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
1-3	Nomenclature and Classification: Biosystematics – introduction and significance; history of nomenclature of cultivated plants.	10

4-6 7-8	Classification and nomenclature systems; International code of nomenclature for cultivated plants	10 5
9-11 12-14 15-16	Identification and Description: Methods of identification Description of cultivated fruit and nut species and their wild relatives features. Development of plant keys for systematic identification and classification.	10 10 5
17-20 21-22	Development of fruit crop descriptors- based upon Biodiversity. International Descriptors and UPOV/ DUS test guidelines.	10 5
23-24	Botanical and pomological description of major cultivars and rootstocks of tropical, subtropical and temperate fruits and nut crops.	10
25-26 27-28 29-32	Registration and Modern Systematics. Registration, Use of chemotaxonomy. Biochemical and molecular markers in modern systematics.	10 5 10

Practical:

Practicals No.	**Topic**
1-6	Exercises on identification and pomological description of various fruit species and cultivars.
7-10	Development of descriptive blanks vis-a-vis UPOV/ DUS test guidelines and Biodiversity International.
11-14	Descriptors for developing fruit species and cultivar descriptive databases.
15-16	Visits to major germplasm centers and field gene banks.

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. 2ndEdn. 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

Course Title: Canopy Management of Fruit Crops

Course Code: FSC 506

Credit Hours: (1+1)

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.

PRACTICALS

1. Study of different types of canopies
2. Training of plants for different canopy types
3. Canopy development through pruning
4. Understanding bearing behaviour and canopy management in different fruits
5. Use of plant growth regulators
6. Geometry of planting
7. Development of effective canopy with support system
8. Study on effect of different canopy types on production and quality of fruits

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
1-2	Introduction, Types and Classification: Canopy management.	15
3-4	Importance and factors affecting canopy development.	10
5-6	Canopy types and structures.	10
7-8	Canopy manipulation for optimum utilization of light and its interception.	10

9	Spacing and utilization of land area – Canopy classification.	5
10-11	Physical Manipulation and Growth Regulation: Canopy management through rootstock and scion.	15
12-13	Canopy management through plant growth regulators.	10
14	Training and pruning and management practices.	10
15-16	Canopy development and management in relation to growth, flowering, fruiting and fruit quality.	15

Practical:

Practicals No.	**Topic**
1-2	Study of different types of canopies.
3-4	Training of plants for different canopy types.
5-6	Canopy development through pruning.
7-8	Understanding bearing behaviour and canopy management in different fruits.
9-10	Use of plant growth regulators.
11	Geometry of planting.
12-13	Development of effective canopy with support system.
14-16	Study on effect of different canopy types on production and quality of fruits.

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

Course Title: Growth and Development of Fruit Crops

Course Code: FSC 507

Credit Hours: (2+1)

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.

PRACTICALS

1. Understanding dormancy mechanisms in fruit crops and seed stratification
2. Techniques of growth analysis
3. Evaluation of photosynthetic efficiency under different environments
4. Exercises on hormone assays
5. Practicals on use of growth regulators
6. Understanding ripening phenomenon in fruits
7. Study on impact of physical manipulations on growth and development
8. Study on chemical manipulations on growth and development
9. Understanding stress impact on growth and development

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
1-3	General Concepts and Principles: Growth and development- definition, parameters of growth and development.	10
4-6	Growth dynamics and morphogenesis.	10
7-10	Climatic Factors, Hormones and Developmental Physiology: Environmental impact on growth and development-	10
11-15	Effect of light, temperature, photosynthesis and photoperiodism, vernalisation, heat units and thermoperiodism.	10
16-18	Assimilate partitioning, influence of water and mineral nutrition in growth and development; concepts of plant hormone and bioregulators, history, biosynthesis and physiological	10
19-22	Role of auxins, gibberellins, cytokinins, abscissic acid, ethylene, growth inhibitors and retardant, brasssinosteroids other new PGRs.	10
23-25	Developmental physiology and biochemistry during dormancy, bud break, juvenility,	10
26-27	Vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development.	10
28-30	Strategies for Overcoming Stress: Growth and developmental process during stress – manipulation of growth and development, impact of pruning and training.	10
31-32	Chemical manipulations and Commercial application of PGRs in fruit crops, molecular and genetic approaches in plant growth and development.	10

Practical:

Practicals No.	Topic
1-2	Understanding dormancy mechanisms in fruit crops and seed stratification.
3-4	Techniques of growth analysis.
5-6	Evaluation of photosynthetic efficiency under different environments.
7-9	Exercises on hormone assays.
10-11	Practical on use of growth regulators.
12-13	Understanding ripening phenomenon in fruits.
14	Study on impact of physical manipulations on growth and development.
15	Study on chemical manipulations on growth and development.
16	Understanding stress impact on growth and development.

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.
- Epstein E. 1972. Mineral Nutrition of Plants: Principles and Perspectives. John Wiley & Sons, 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.

Course Title: Nutrition of Fruit Crops

Course Code: FSC 508

Credit Hours: (2+1)

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, biofertilizers and their use in INM systems. Site specific nutrient management, nutrient management for fruit nursery.

PRACTICALS

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

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
1-3	General Concepts and Principles: Importance and history of nutrition in fruit crops, essential plant nutrients,	10
4-5	Factors affecting plant nutrition; nutrient uptake and their removal from soil.	10
6-9	Diagnostics, Estimation and Application: Nutrient requirements, root distribution in fruit crops.	10
10-13	Soil and foliar application of nutrients in major fruit crops, fertilizer use efficiency.	10
14-18	Methods and techniques for evaluating the requirement of macro- and micro-elements,	10
19-22	Diagnostic and interpretation techniques including DRIS.	10
23-24	Role of different macro and micro-nutrients,	5
25-26	Their deficiency and toxicity disorders,	10
27-28	Corrective measures to overcome deficiency and toxicity disorders.	5
29	Integrated Nutrient Management (INM)	5
30	Fertigation in fruit crops, biofertilizers and their use in INM systems.	10
31-32	Site specific nutrient management, nutrient management for fruit nursery.	5

Practical:

Practical's No.	Topic
1-2	Visual identification of nutrient deficiency symptoms in fruit crops.
3	Identification and application of organic, inorganic and bio-fertilizers.
4	Soil/ tissue collection and preparation for macro- and micro-nutrient analysis.
5	Analysis of soil physical and chemical properties- pH, EC, Organic carbon.
6-11	Determination of N,P,K and other macro- and micronutrients.
12-13	Fertigation in protected structure and field grown horticultural crops.
14-16	Preparation of micro-nutrient solutions, their spray and soil applications.

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.

Course Title: Biotechnology of Fruit Crops

Course Code: FSC 509

Credit Hours: (2+1)

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.

PRACTICALS

1. 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
5. Protoplast culture and fusion technique
6. Development of protocols for mass multiplication
7. Project development for establishment of commercial tissue culture laboratory

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
1-3	Introduction, History and Basic Principles: Introduction and significance, history and basic principles, influence of explant material,	10
4-6	Physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture.	10
7-10	In-vitro Culture and Hardening: Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis;	10
11-13	Organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture.	10
14-19	Use of bioreactors and in-vitro methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues.	15
20-21	Hardening and ex vitro establishment of tissue cultured plants.	5
22-24	In-vitro Breeding, Transgenics and Gene Technologies: Somatic cell hybridisation, construction and identification of somatic hybrids and cybrids, wide hybridization,	10
25-26	In-vitro pollination and fertilization, haploids, in-vitro mutation,	5
27-28	Artificial seeds, cryopreservation, In-vitro selection for biotic and abiotic stress.	5
29-30	Genetic engineering- principles and methods, transgenics in fruit crops, use of molecular markers and genomics.	10
31-32	Gene silencing, gene tagging, gene editing, achievements of biotechnology in fruit crops.	10

Practical:

Practicals No.	Topic
1-2	An exposure to low cost, commercial and homestead tissue culture laboratories.
3-5	Media preparation, Inoculation of explants for clonal propagation, callus induction and culture, regeneration of plantlets from callus.
6-9	Sub-culturing techniques on anther, ovule, embryo culture, somaclonal variation.
10-11	In-vitro mutant selection against abiotic stress.

12-13	Protoplast culture and fusion technique.
14-15	Development of protocols for mass multiplication.
16	Project development for establishment of commercial tissue culture laboratory.

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. NarosaPublishing 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.

Course Title: Organic Fruit Culture

Course Code: FSC 510

Credit Hours: (2+1)

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 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.

Practicals

1. Design of organic orchards/ farms management
2. Conversion plan
3. Nutrient management and microbial assessment of composts and bio-enhancers
4. Preparation and application of composts, bio-enhancers and bio-pesticides
5. Organic nursery raising
6. Application of composts, bio-enhancers, bio-fertilisers and bio-pesticides, green manure, cover, mulching
7. Preparation and use of neem based products
8. Biodynamic preparations and their role in organic agriculture, EM technology and products, biological/ natural management of pests and diseases
9. Soil solarisation
10. Frame work for GAP
11. Documentation for certification

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
1-3	Principles and Current Scenario: Organic horticulture, scope, area, production and world trade, definition, principles, methods and SWOT analysis.	10
4-6	Farming System and Practices: Organic farming systems including biodynamic farming, natural farming, homa organic farming, rishi krishi, EM technology, cosmic farming;	10
7-9	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.	10
10-13	Organic seeds and planting materials, soil health management in organic production, weed management practices in organic farming,	10
14-16	Biological management of pests and diseases, trap crops, quality improvement in organic production of fruit crops.	10
17-19	Inspection, Control Measures and Certification: Inspection and	10

20-22	certification of organic produce. Participatory guarantee system (PGS), NPOP, documentation and control, development of internal control system (ICS).	10
23-24 25-26	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.	10 10
27-31 32	Constraints in certification, IFOAM and global scenario of organic movement, postharvest management of organic produce. Economics of organic fruit production.	5 5

Practical:

Practicals No.	**Topic**
1	Design of organic orchards/ farms management.
2	Conversion plan.
3-4	Nutrient management and microbial assessment of composts and bio-enhancers.
5-6	Preparation and application of composts, bio-enhancers and bio-pesticides.
7	Organic nursery raising.
8-9	Application of composts, bio-enhancers, bio-fertilisers and bio-pesticides, green manure, cover, mulching.
10	Preparation and use of neem based products.
11-12	Biodynamic preparations and their role in organic agriculture, EM technology and products, biological/ natural management of pests and disease.
13	Soil solarisation.
14	Frame work for GAP
15-16	Documentation for certification

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.

Course Title: Export Oriented Fruit Production

Course Code: FSC 511

Credit Hours: (2+1)

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, Citrus, 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.

PRACTICAL:

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

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
1-3	Statistics and World Trade: National and international fruit export and import scenario and trends;	10
4-6	Statistics and India's position and potentiality in world trade; export promotion zones in India. Government Policies.	10
7		5
8-10	Policies, Norms and Standards: Scope, produce specifications.	10
11-16	Quality and safety standards for export of fruits, viz., mango, banana, Citrus, grape, litchi, pomegranate, walnut, apple and other important fruits.	15
17-22	Processed and value-added products, post harvest management for export including packaging and cool chain; HACCP, Codex alimentarius,	15
23-24	ISO certification; WTO and its implications, sanitary and phyto-sanitary measures.	10
25-26	Infrastructure and Plant Material: Quality fruit production under protected environment.	10
27-30	Different types of structures – Automated greenhouses, glasshouse, shade net, poly tunnels .	5
31-32	Design and development of low cost greenhouse structures. Seed and planting material; meeting export standards, implications of plant variety protection – patent regimes.	10

Practical:

Practicals No.	Topic
1	Export promotion zones and export scenario of fresh fruits and their products
2-3	Practical exercises on quality standards of fruits for export purpose
4-5	Quality standards of planting material and seeds
6	Hi-tech nursery in fruits
7-9	Practicals on ISO specifications and HACCP for export of fruits
10-11	Sanitary and phyto-sanitary measures during export of horticultural produce
12-15	Post harvest management chain of horticultural produce for exports
16	Visit to export oriented units/ agencies like APEDA, NHB, etc.

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

Course Title: Climate Change and Fruit Crops

Course Code: FSC 512

Credit Hours: (1+0)

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.

Block 2: **Climate Change and Management**

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 – CO2 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

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
1-2	Introduction, Global Warming and Climatic Variability: Introduction to climate change. Factors directly affecting climate change.	10
3-4	Global warming, effect of climate change on spatio-temporal patterns of temperature and rainfall, concentrations of greenhouse gasses in atmosphere.	10
5	Pollution levels such as tropospheric ozone, change in climatic variability and extreme events.	5
6	Impact Assessment and Mitigation:	5
7-8	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.	10
9-10	Climate mitigation measures through crop management- use of tolerant rootstocks and varieties,	10
11	Mulching – use of plastic- windbreak- spectral changes- protection from frost and heat waves.	5
12	Climate management in greenhouse- heating – vents – CO2 injection – screens – artificial light.	10
13-14	Impact of climate changes on invasive insect, disease, weed, fruit yield, quality and sustainability.	10
15	Climate management for control of pests, diseases, quality, elongation of growth and other plant processes- closed production systems.	15
16	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	10

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.

Course Title: Minor Fruit Production

Course Code: FSC 513

Credit Hours: (2+1)

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, Tamarind, Marking nut Ber, Fig, Jamun, Persimmon Woodapple, Karonda, Kokum, Mhua, khirni, Passion fruit, Dragon fruit Khejri, Kair, Pilu, Lasoda, Loquat Monkey jack, Chronji, Amra, Phalsa, Cactus Pear Cape Gooseberry, Kaphal Pistachio, Seabuckthorn, Hazel nut other minor fruits of regional importance of minor fruits plants/ cultivars

PRACTICAL:

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

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
	Occurrence, Adoption and General Account: Importance – occurrence and distribution, climate adaptation in fragile ecosystem and wastelands. 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. 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	
1-4	Bael, Tamarind, Marking nut	15
5-7	Ber, Fig, Jamun, Persimmon	15
8-11	Woodapple, Karonda, Kokum,	15
12-15	Mahua, khirni, Passion fruit, Dragon fruit	15
16-19	Khejri, Kair, Pilu, Lasoda, Loquat	15
20-22	Monkey jack, Chironji,	5
23-25	Amra, Phalsa, Cactus Pear	5
26-27	Cape Gooseberry, Kaphal	5
28-29	Pistachio, Seabuckthorn, Hazel nut	5
30-32	other minor fruits of regional importance of minor fruits plants/ cultivars	5

Practical:

Practicals No.	Topic
1-2	Visits to institutes located in the hot and cold arid regions of the country
3-4	Identification of minor fruits plants/ cultivars
5	Collection of leaves and preparation of herbarium
6-7	Allelopathic studies
8-11	Generating know-how on reproductive biology of minor fruits
12-15	Fruit quality attributes and biochemical analysis
16	Project formulation for establishing commercial orchards in fragile ecosystems

Suggested Reading

- Ghosh SN, Singh A and Thakur A. 2017. Underutilized Fruit Crops: Importance and Cultivation. Jaya Publication House, New Delhi.
- Krishna H and Sharma RR, 2017. Fruit Production: Minor Fruits. Daya Publishing House, New Delhi.
- Mazumdar BC. 2014. Minor Fruit Crops of India: Tropical and Subtropical. Daya Publication House, New Delhi.
- Nath V, Kumar D, Pandey V and Pandey D. 2008. Fruits for the Future. Satish Serial Publishing House, New Delhi.
- Pareek OP, Sharma S, and Arora RK. 2007. Underutilised Edible Fruits and Nuts, IPGRI, Rome.
- Peter KV. 2010. Underutilized and Underexploited Horticultural Crops. NIPA, New Delhi.
- Rana JC and Verma VD. 2011. Genetic Resources of Temperate Minor Fruit (Indigenous and Exotic). NBPGR, New Delhi.
- Saroj PL and Awasthi OP. 2005. Advances in Arid Horticulture, Vol. II: Production Technology of Arid and Semiarid Fruits. IBDC, Lucknow.
- Saroj PL, Dhandar DG and Vashishta BB. 2004. Advances in Arid Horticulture, Vol.-1 Present Status. IBDC, Lucknow.
- Singh et al. 2011. Jamun. ICAR, New Delhi.

8. COURSE CONTENTS OF DOCTORAL DEGREE

Course Title: Innovative Approaches in Fruit Breeding

Course Code: FSC 601

Credit Hours: (3+0)

THEORY:

Block 1: Introduction

Unit I: Current Trends and Status: Modern trends in fruit breeding –with major emphasis on precocity, low tree volume, suitability for mechanization, health benefits, etc.

Block 2: **Genetic Mechanisms**

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

Block 3: Breeding for Specific Traits

Unit I: Plant Architecture, Stress Tolerance and Fruit Quality: Recent advances in crop improvement efforts- wider adaptation, plant architecture, amenability to mechanization, fruit quality attributes, stress tolerance, crop specific traits; use of apomixis, gene introgression and wide hybridization (alien genes).

Block 4: Fast-Track Breeding

Unit I: Transgenics, Markers and Genomics: Molecular and transgenic approaches in improvement of selected fruit crops; fast track breeding– marker assisted selection and breeding (MAS and MAB), use of genomics and gene editing tehnologies.

Crops

Mango Banana Guava Papaya Citrus Grapes Pomegranate and Annona Litchi, Apple Peaches, Pear Strawberry, Kiwifruit Apricot, Cherries Nectarins, Nut crops

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
Block-1 Block-2 Block-3 Block-4	Current Trends and Status: Modern trends in fruit breeding –with major emphasis on precocity, low tree volume, suitability for mechanization, health benefits, etc. Inheritance Patterns and Breeding Systems: Genetics of important traits and their inheritance pattern, variations and natural selection, spontaneous mutations, incompatibility systems in fruits. Plant Architecture, Stress Tolerance and Fruit Quality: Recent advances in crop improvement efforts- wider adaptation, plant architecture, amenability to mechanization, fruit quality attributes, stress tolerance, crop specific traits; use of apomixis, gene introgression and wide hybridization (alien genes). Transgenics, Markers and Genomics: Molecular and transgenic approaches in improvement of selected fruit crops; fast track breeding– marker assisted selection and breeding (MAS and MAB), use of genomics and gene editing tehnologies.	
1-4	Mango	10
5-8	Banana	10
9-12	Guava	10
13-16	Papaya	10
17-20	Citrus	10
21-24	Grapes	10
25-34	Pomegranate and Annona	10
35-39	Litchi, Apple	10
40-41	Peaches, Pear	5
42-43	Strawberry, Kiwifruit	5
44-45	Apricot, Cherries	5
46-48	Nectarins, Nut crops	5

Suggested Reading

- Al-Khayari J, Jain SN and Johnson DV. 2018. Advances in Plant Breeding Strategies. Vol. 3: Fruits. Springer.
- Badenes S and Byrne DH. 2012. Fruit Breeding. Springer.
- Hancock JF. 2008. Temperate Fruit Crop Breeding: Germplasm to Genomics. Springer.
- Kole C and Abbott AG. 2012. Genetics, Genomics and Breeding of Stone fruits. CRC.
- Kole, C. 2011. Wild Crops Relatives: Genomics and Breeding Resources: Tropical and Subtropical Fruits. Springer-Verlag.
- Kole C. 2011. Wild Crops Relatives: Genomics and Breeding Resource: Temperate Fruits. Springer -Verlag.
- Jain SN and Priyadarshan PM. 2009. Breeding Plantation and Tree Crops: Tropical Species; Temperate Species. Springer -Verlag.
- Janick J and Moore JN, 1996. Fruit Breeding. Vols.I-III. John Wiley & Sons, USA.
- Orton T. 2019. Methods in Fruit Breeding. Elsevier.
- Singh SK, Patel VB, Goswami AK, Prakash J and Kumar C. 2019. Breeding of Perennial Horticultural Crops. Biotech Books. Delhi.

Course Title: Modern Trends in Fruit Production

Course Code: FSC 602

Credit Hours: (3+0)

THEORY:

Block 1: Introduction

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

Block 2: Advanced Technologies

Unit I: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation – root stocks, planting systems, High density planting, crop modeling, Precision farming, decision support systems – aspects of crop regulation- physical and chemical regulation.

Block 3: Management Practices

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

Crops

Mango Banana Grape Citrus Papaya Sapota Guava Pomegranate Apple, Peaches, Litchi Pear, Plum, Apricot Cherry, Almond Walnut, Pecan Strawberry, Kiwifruit

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	**Topic**	**Weightage (%)**
Block-1 Block-2 Block-3	General Concepts and Current Scenario: National and International scenario, national problems. Propagation, Planting Systems and Crop Regulation: Recent advances in propagation – root stocks, planting systems, High density planting, crop modeling, Precision farming, decision support systems – aspects of crop regulation- physical and chemical regulation. Overcoming Stress and Integrated Approaches: Effects on physiology and development, influence of stress factors, strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, Physiological disorders, Total quality management (TQM)– Current topics.	
1-4	Mango	10
5-8	Banana	10
9-12	Grape	10
13-16	Citrus	10
17-20	Papaya	10
21-24	Sapota	5
25-28	Guava	10
29-32	Pomegranate	5
33-36	Apple, Peaches, Litchi	10
37-39	Pear, Plum, Apricot	5
40-42	Cherry, Almond	5
43-44	Walnut, Pecan	5
45-48	Strawberry, Kiwifruit	5

Suggested Reading

- Bartholomew DP, Paull RE and Rohrbach KG. eds. 2002. The Pineapple: Botany, Production, and Uses. CAB International.
- Bose TK, Mitra SK and Sanyol D. Eds. 2002. Fruits of India – Tropical and Sub- Tropical. 3rd Ed. Vols. I, II. Naya Udyog, Kolkata, India.
- Dhillon WS and Bhatt ZA. 2011. Fruit Tree Physiology. Narendra Publishing House, New Delhi.
- Dhillon WS. 2013. Fruit Production in India. Narendra Publishing House, New Delhi.
- Gowen S. 1995. Bananas and Plantains. Chapman & Hall Publication, US.
- Litz RE. ed. 2009. The Mango: Botany, Production and Uses. CAB International.
- Peter KV. 2016. Innovations in Horticulture. NIPA, New Delhi.
- Robinson JC and Saúco VG. 2010. Bananas and Plantains (Vol. 19). CAB International.
- Samson JA. 1980. Tropical Fruits. Longman, USA.
- Sharma RR and Krishna H. 2014. Fruit Production: Major Fruits. Daya Publishing House, Delhi.
- Singh S, Shivankar VJ, Srivastava AK and Singh IP. 2004. Advances in Citriculture. Jagmander Book Agency, New Delhi.
- Stover RH and Simmonds NW. 1991. Bananas. Longman, USA.
- Chadha KL, Ahmed N, Singh SK and Kalia P. 2016. Temperate Fruits and Nuts- Way Forward for Enhancing Production and Quality.Daya Publishing House, New Delhi.
- Childers NF, Morris JR and Sibbett GS. 1995. Modern Fruit Science: Orchard and Small Fruit Culture. Horticultural Publications, USA.
- Erez A. 2013. Temperate Fruit Crops in Warm Climates. Springer Science.
- Jackson D, Thiele G, Looney NE and Morley-Bunker M. 2011. Temperate and Subtropical Fruit Production. CAB International.
- Ryugo K. 1998. Fruit Culture: Its Science and Art. John Wiley & Sons, USA.
- Tromp J, Webster AS and Wertheim SJ. 2005. Fundamentals of Temperate Zone Tree Fruit Production. Backhuys Publishers, Lieden, The Netherlands.
- Westwood MN. 2009. Temperate Zone Pomology: Physiology and Culture. 3rdEdn. Timber Press, USA.

Course Title: Recent Developments in Growth Regulation

Course Code: FSC 603

Credit Hours: (3+0)

THEORY:

Block 1: Introduction

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

Block 2: Growth Substances

Unit I: Phytohormones and Growth Regulators: Root and canopy regulation, study of plant growth regulators in fruit culture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants. Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards

Block 3: **Growth and Development**

Unit I: Regulation of Developmental Processes: Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production. Flower drop and thinning, fruit-set and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, molecular approaches in crop growth regulation- current topics.

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
Block-1 Block-2 Block-3	Current Concepts and Principles: Eco-physiological influences on growth and development of fruit crops-flowering, fruit set- Crop load and assimilate partitioning and distribution. Phytohormones and Growth Regulators: Root and canopy regulation, study of plant growth regulators in fruit culture-structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants. Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, canopy management for fertigated orchards. Regulation of Developmental Processes: Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, fruit bud initiation, regulation of flowering, off season production. Flower drop and thinning, fruit-set and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, molecular approaches in crop growth regulation- current topics.	
1-5 6-9	Eco-physiological influences on growth and development of fruit crops. Flowering, fruit set- crop load and assimilate partitioning and distribution.	10 5
10-14 15-18	Root and canopy regulation, study of plant growth regulators in fruit culture Structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants	10 10
19-21 22-26 27-30	Absorption, translocation and degradation of phytohormones Internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition. Canopy management for fertigated orchards.	5 10 5
31-34 35-38 39	Growth regulation aspects of propagation. Embryogenesis, seed and bud dormancy, fruit bud initiation. Regulation of flowering, off season production.	10 10 5
40-44 45-48	Flower drop and thinning, fruit-set and development, fruit drop, parthenocarpy, fruit maturity and ripening and storage, Molecular approaches in crop growth regulation- current topics.	10 10

Suggested Reading

- Bhatnagar P. 2017. Physiology of Growth and Development of Horticultural Crops. Agrobios (India).
- Buchanan B, Gruiessam W and Jones R. 2002. Biochemistry and Molecular Biology of Plants. John Wiley & Sons, US.
- Fosket DE. 1994. Plant Growth and Development: A Molecular Approach. Academic Press, USA.
- Leopold AC and Kriedermann PE. 1985. Plant Growth and Development. 3rd Ed. McGraw-Hill, US.
- Richard N. Arteca. 1995. Plant Growth Substances – Principles and Applications. Chapman & Hall, USA.
- Roberts J, Downs S and Parker P. 2002. Plant Growth Development. In: Plants (I. Ridge, Ed.), Oxford University Press.
- Salisbury FB and Ross CW. 1992. Plant Physiology. 4th Ed. Wadsworth Publication.

Course Title: Advanced Laboratory Techniques

Course Code: FSC 604

Credit Hours: (1+2)

THEORY:

Block 1: General Aspects

Unit 1 Safety Measures and Laboratory Maintenance: Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.

Block 2: Qualitative and Quantitative Analysis

Unit I: Destructive and Non-destructive Analysis Methods: Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops.

Unit II: Chromatographic and Microscopic Analysis: Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in horticultural produce

Unit III: Sensory Analysis: Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.

Practical:

1. Determination of moisture, relative water content and physiological loss in weight
2. Determination of biochemical components in horticultural produce
3. Calibration and standardization of instruments
4. Textural properties of harvested produce
5. Determination of starch index (SI)
6. Specific gravity for determination of maturity assessment, and pH of produce
7. Detection of adulterations in fresh as well as processed products
8. Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch

9. Estimation of rate of ethylene evolution using gas chromatograph (GC)
10. Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, etc.

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
Block-1 Block-2	Safety Measures and Laboratory Maintenance: Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity. Destructive and Non-destructive Analysis Methods: Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops. Chromatographic and Microscopic Analysis: Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in horticultural produce. Sensory Analysis: Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.	
1 2-3	Safety Measures and Laboratory Maintenance: Safety aspects and upkeep of laboratory, Sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce.	5 10
4-5 6	Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, Textural properties of harvested produce, TSS, Specific gravity, pH and acidity.	10 5
7-8	Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops.	15

9-10 11-12	Chromatographic and Microscopic Analysis: Basic chromatographic techniques,. GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration.	10 10
13 14	Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability. Determination of biochemical components in horticultural produce.	15 5
15-16	Sensory Analysis: Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.	15

Practical:

Practicals No.	Topic
1-4	Determination of moisture, relative water content and physiological loss in weight
5-8	Determination of biochemical components in horticultural produce
9-12	Calibration and standardization of instruments
13-15	Textural properties of harvested produce
16-18	Determination of starch index (SI)
19-21	Specific gravity for determination of maturity assessment, and pH of produce
22-24	Detection of adulterations in fresh as well as processed products
25-27	Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch
28-30	Estimation of rate of ethylene evolution using gas chromatograph (GC)
31-32	Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, etc.

Suggested Reading

- AOAC International. 2003. Official Methods of Analysis of AOAC International. 17th Ed. Gaithersburg, MD, USA, Association of Analytical Communities, USA.
- Clifton M and Pomeranz Y. 1988. Food Analysis-Laboratory Experiments. AVI Publication, USA.
- Leo ML. 2004. Handbook of Food Analysis. 2nd Ed. Vols. I-III, USA.
- Linskens HF and Jackson JF. 1995. Fruit Analysis. Springer.
- Pomrenz Y and Meloan CE. 1996. Food Analysis – Theory and Practice. CBS, USA.
- Ranganna S. 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw-Hill, New Delhi.
- Thompson AK. 1995. Post Harvest Technology of Fruits and Vegetables. Blackwell Sciences. USA.

Course Title: Arid and Dryland Fruit Production

Course Code: FSC 605

Credit Hours: (2+0)

THEORY:

Block 1: Introduction

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

Block 2: Advanced Technologies

Unit I: Propagation, Planting Systems and Crop Regulation: Recent advances in propagation – root stocks, planting systems, High density planting, crop modelling, Precision farming, decision support systems – aspects of crop regulation- physical and chemical regulation, effects on physiology and development, influence of stress factors.

Block 3: Management Practices

Unit I: Stress Mitigation and Integrated Approaches: Strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, total quality management (TQM) – Current topics.

Crops

Aonla, Annona Ber, Bael, Jamun, FigDate palm, Tamarind Woodapple, Karonda Marking Nut, Mahua, Khirni Phalsa, Lasoda, Manila, Khejri Monkey jack, Amra-Kair, pilu Seabuckthorn, Chilgoza, Cactus pear Cafel, Box myrtle, Chironji, Paniala

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
Block-1 Block-2 Block-3	General Concepts and Current Scenario: Characteristics features and major constraints of the arid and dryland region, distinguishing features of the fruit species trees for adaptation in adapting to the region, nutritional and pharmaceutical importance, national problems. Propagation, Planting Systems and Crop Regulation: Recent advances in propagation – root stocks, planting systems, High density planting, crop modelling, Precision farming, decision support systems – aspects of crop regulation- physical and chemical regulation, effects on physiology and development, influence of stress factors. Stress Mitigation and Integrated Approaches: Strategies to overcome stress effects, integrated and modern approaches in water and nutrient management, total quality management (TQM) – Current topics.	
1-3	Aonla, Annona	15
4-6	Ber, Bael,	10
7-9	Jamun, Fig	15
10-12	Date palm, Tamarind	10
13-15	Wood Apple, Karonda	10
16-18	Marking Nut, Mahua, Khirni	10
19-21	Phalsa, Lasoda, Manila, Khejri	5
22-23	Monkey jack, Amra	5
24-25	Kair, pilu	5
26-27	Seabuckthorn, Chilgoza, Cactus pear	5
28-29	Cafel,	5
30-32	Box myrtle, Chironji, Paniala	5

Suggested Reading

- Hiwale S. 2015. Sustainable Horticulture in Semiarid Drylands. Springer.
- Krishna H and Sharma RR. 2017. Fruit Production – Minor Fruits.Daya Publishing House, Delhi.
- More T A, Singh RS, Bhargava R and Sharma BD. 2012. Arid Horticulture for Nutrition and Livelihood. Agrotech Publishing Academy, Udaipur (Rajasthan).
- Pareek OP, Sharma S and Arora RK. 2007. Underutilised Edible Fruits and Nuts, IPGRI, Rome.
- Peter K.V. 2010. Underutilized and Underexploited Horticultural Crops. NIPA, New Delhi.
- Saroj PL, Dhandar DG and Vashishta BB. 2004. Advances in Arid Horticulture, Vol.-1 Present Status. IBDC, Lucknow.
- Saroj P L and Awasthi OP. 2005. Advances in Arid Horticulture, Vol: II: Production Technology of Arid and Semiarid Fruits. IBDC, Lucknow.
- Sontakke MB. 2014. Production and Management of Fruit crops in Arid/ Drylands. Agrotech Publishing Academy, Udaipur (Rajasthan).

Course Title: Abiotic Stress Management in Fruit Crops

Course Code: FSC 606

Credit Hours: (2+1)

THEORY:

Block 1: Introduction

Unit I: Basic Aspects and Principles: Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.). Pollution – increased level of CO2, industrial wastes, impact of stress in fruit crop production, stress indices, physiological and biochemical factors associated with stress, fruit crops suitable for different stress situations.

Block 2: Stress ImpactUnit I: Assessment, Physiology and Performance: Crop modeling for stress situations, cropping systems, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stresses and their impact on crop growth and productivity.

Block 3: Stress Management

Unit I: Mitigation Measures and Conservation Practices: Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers. Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, stability and sustainability indices.

PRACTICAL

1. Seed treatment/ hardening practices
2. Container seedling production
3. Analysis of soil moisture estimates (FC, ASM, PWP)
4. Analysis of plant stress factors, RWC, chlorophyll flourosence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate, etc. under varied stress situations
5. Biological efficiencies, WUE, solar energy conversion and efficiency
6. Crop growth sustainability indices and economics of stress management

7. Visit to orchards and watershed locations

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
Block-1 Block-2 Block-3	Basic Aspects and Principles: Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.). Pollution – increased level of CO2, industrial wastes, impact of stress in fruit crop production, stress indices, physiological and biochemical factors associated with stress, fruit crops suitable for different stress situations. Assessment, Physiology and Performance: Crop modeling for stress situations, cropping systems, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stresses and their impact on crop growth and productivity. Mitigation Measures and Conservation Practices: Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs in stress management, mode of action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers. Rain water harvesting, increasing water use efficiency, skimming technology, contingency planning to mitigate different stress situations, stability and sustainability indices.	
1-3 4-6	Stress – definition, classification, stresses due to water (high and low), temperature (high and low), radiation, wind. Soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.).	10 10
7-9 10-12	Pollution – increased level of CO2, industrial wastes, impact of stress in fruit crop production, stress indices, Physiological and biochemical factors associated with stress, fruit crops suitable for different stress situations.	10 10
13-14 15-17	Crop modeling for stress situations, cropping systems, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress. Interaction among different stresses and their impact on crop growth and productivity.	10 10
18-22 23-25	Greenhouse effect and methane emission and its relevance to abiotic stresses. Use of anti transpirants and PGRs in stress management.Mode of	10

	action and practical use, HSP inducers in stress management techniques of soil moisture conservation, mulching, hydrophilic polymers.	10
26-29	Rain water harvesting, increasing water use efficiency.	10
30-32	Skimming technology, contingency planning to mitigate different stress situations, stability and sustainability indices.	10

Practical:

Practicals No.	Topic
1-2	Seed treatment/ hardening practices
3-4	Container seedling production
5	Analysis of soil moisture estimates (FC, ASM, PWP)
6-10	Analysis of plant stress factors, RWC, chlorophyll flourosence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate, etc. under varied stress situations
11-12	Biological efficiencies, WUE, solar energy conversion and efficiency
13-14	Crop growth sustainability indices and economics of stress management
15-16	Visit to orchards and watershed locations

Suggested Reading

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

Course Title: Biodiversity and Conservation of Fruit Crops

Course Code: FSC 607

Credit Hours: (2+1)

THEORY:

Block 1: General Aspects

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

Block 2: Germplasm Conservation

Unit I: Collection, Maintenance and Characterization: Exploration and collection of germplasm; sampling frequencies; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- in situ and ex situ strategies, on farm conservation; problem of recalcitrancy- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

Block 3: Regulatory Horticulture

Unit I: Germplasm Exchange, Quarantine and Intellectual Property Rights: Regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phyto-sanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India.

Practical:

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

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
Block-1 Block-2 Block-3	Issues, Goals and Current Status: Biodiversity and conservation; issues and goals- needs and challenges; present status of gene centres; world's major centres of fruit crop domestication; current status of germplasm availability/ database of fruit crops in India. Collection, Maintenance and Characterization: Exploration and collection of germplasm; sampling frequencies; size and forms of fruit and nut germplasm collections; active and base collections. Germplasm conservation- in situ and ex situ strategies, on farm conservation; problem of recalcitrancy- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage. Germplasm Exchange, Quarantine and Intellectual Property Rights: Regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phyto-sanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India.	
1-5	Biodiversity and conservation; issues and goals- needs and challenges; present status of gene centres; world's major centres of fruit crop domestication.	20
6	Current status of germplasm availability/ database of fruit crops in India.	10
7-10	Exploration and collection of germplasm; sampling frequencies; size and forms of fruit and nut germplasm collections; active and base collections.	10
11-12	Germplasm conservation- in situ and ex situ strategies, on farm conservation.	10
13-15	Problem of recalcitrancy- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.	10
16- 24	Regulatory horticulture, inventory and exchange of fruit and nut germplasm, plant quarantine, phyto-sanitary certification, detection of genetic constitution of germplasm and maintenance of core collection.	15
25-28	IPRs, Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity.	10

29-32	Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged fruit varieties in India.	15

Practical:

Practicals No.	Topic
1-2	Documentation of germplasm- maintenance of passport data and other records of accessions
3-4	Field exploration trips and sampling procedures
5-6	Exercise on ex situ conservation – cold storage, pollen/ seed storage
7-8	Cryopreservation
9-10	Visits to National Gene Bank and other centers of PGR activities
11-12	Detection of genetic constitution of germplasm
13-14	Germplasm characterization using a standardised DUS test protocol
15-16	Special tests with biochemical and molecular markers

Suggested Reading

- Dhillon BS, Tyagi RK, Lal A and Saxena S. 2004. Plant Genetic Resource Management. – Horticultural Crops.Narosa Publishing House, New Delhi.
- Engles JM, Ramanath RV, Brown AHD and Jackson MT. 2002. Managing Plant Genetic Resources, CABI, Wallingford, UK.
- Frankel OH and Hawkes JG. 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press, USA.
- Hancock J. 2012. Plant Evolution and the Origin of Crops Species. CAB International.
- Jackson M, Ford-Lloyd B and Parry M. 2014. Plant Genetic Resources and Climate Change. CABI, Wallingford, UK.
- Moore JN and Ballington Jr, JR. 1991. Genetic Resources of Temperate Fruit and Nut Crops. ISHS, Belgium.
- Peter KV. 2008. Biodiversity of Horticultural Crops. Vol. II. Daya Publ. House, Delhi.
- Peter KV. 2011. Biodiversity in HorticulturalCrops.Vol.III. Daya Publ. House, Delhi.
- Rana JC and Verma VD. 2011. Genetic Resources of Temperate Minor Fruits (Indigenous and Exotic). NBPGR, New Delhi.
- Rajasekharan PE, Rao V and Ramanatha V. 2019. Conservation and Utilization of Horticultural Genetic Resources. Springer.
- Sthapit B, et al. 2016. Tropical Fruit Tree Diversity (Good Practices for in situ and ex situ conservation). Bioversity International. Routledge, Taylor and Francis Group.
- Virchow D. 2012. Conservation of Genetic Resources, Springer Verlag, Berlin

Course Title: Smart Fruit Production

Course Code: FSC 608

Credit Hours: (2+0)

THEORY:

Block 1: Introduction

Unit I: Importance and Overview: Introduction and importance; concepts and applications of artificial intelligence systems; case studies in horticulture.

Block 2: Crop Modelling and Forecasting

Unit I: GIS, Sensors and Wireless Systems: Application of sensors in fruit production, crop monitoring – crop load and stress incidence forecast modules, remote sensing, Geographical Information System (GIS), Differential Geo-Positioning System (DGPS) hi-tech nursery production of fruit crops under protected conditions, ultra modern wireless based drip irrigation network.

Block 3: Nanotechnology

Unit I: Concepts and Methods: Nanotechnology for smart nutrient delivery in fruit farming, concepts and methods, practical utility, nano-fertilizers, nano-herbicides; nano-pesticides

Block 4: Innovative Approaches

Unit I: Mechanization, Automation and Robotics: Production systems amenable to automation and mechanization; automated protected structures (turnkey systems); hydroponics, aeroponics, bioreactors for large scale plant multiplication; Use of drones and robotics in fruit growing – robotic planters, sprayers, shakers, harvesters, stackers, etc. Visit to Hi-tech facilities.

TEACHING SCHEDULE

THEORY:

Block / Lec. No.	Topic	Weightage (%)
Block-1 Block-2 Block-3 Block-4	Importance and Overview: Introduction and importance; concepts and applications of artificial intelligence systems; case studies in horticulture. GIS, Sensors and Wireless Systems: Application of sensors in fruit production, crop monitoring – crop load and stress incidence forecast modules, remote sensing, Geographical Information System (GIS), Differential Geo-Positioning System (DGPS) hi-tech nursery production of fruit crops under protected conditions, ultra modernwireless based drip irrigation network. Concepts and Methods: Nanotechnology for smart nutrient delivery infruit farming, concepts and methods, practical utility, nano-fertilizers, nano-herbicides; nano-pesticides . Mechanization, Automation and Robotics: Production systems amenable to automation and mechanization; automated protected structures (turnkey systems); hydroponics, aeroponics, bioreactors for large scale plant multiplication; Use of drones and robotics in fruit growing – robotic planters, sprayers, shakers, harvesters, stackers, etc. Visit to Hi-tech facilities.	
1-3	Introduction and importance; concepts and applications of artificial intelligence systems; case studies in horticulture	20
4-6	Application of sensors in fruit production, crop monitoring – crop load and stress incidence forecast modules, remote sensing,	10
7-9	Geographical Information System (GIS), Differential Geo-Positioning System (DGPS)	10
10-12	hi-tech nursery production of fruit crops under protected conditions, ultra modernwireless based drip irrigation network.	10
13-18	Nanotechnology for smart nutrient delivery infruit farming, concepts and methods, practical utility, nano-fertilizers, nano-herbicides; nano-pesticides	20
19-24	Production systems amenable to automation and mechanization; automated protected structures (turnkey systems);	10
25-28	hydroponics, aeroponics, bioreactors for large scale plant multiplication;	10
29-32	Use of drones and robotics in fruit growing – robotic planters, sprayers, shakers, harvesters, stackers, etcVisit to Hi-tech facilities.	10

Suggested Reading

- Chadha et al. 2017. Doubling Farmers Incomes through Horticulture. Daya Publishing House, New Delhi.
- Chadha et al. 2019.Shaping the Future of Horticulture. Kruger Brentt Publishers, UK.
- Hewett EW. 2013. Automation, Mechanization and Robotics in Horticulture. In: Workshop on Emerging Postharvest Technologies. UC, Davis, USA.
- Peter KV. 2016. Innovations in Horticulture. NIPA, New Delhi.
- Prasad S, Singh D and Bhardwaj RL. 2012. Hi-Tech Horticulture.Agrobios (India).
- Tyagi, S. 2019. Hi- Tech Horticulture. Vols. 1 to 7. NIPA, New Delhi.
- Zhang Q. 2017. Automation in Tree Fruit production – Principles and Practice. CABI.
- http://horticulture.ucdavis.edu- Innovative Technology for Horticultural Department.

9. List of Journals & e-Resources

1. Advances in Horticultural Science 0394-6169
2. Acta Horticulturae 0567-7572
3. American Journal of Enology and Viticulture 0002-9254
4. Annals of Arid Zone 0570-1791
5. Annals of Horticulture 0974-8784
6. Biodiversity and Conservation 0960-3115
7. Current Horticulture 2347-7377
8. European Journal of Horticultural Science.1611-4426
9. Fruits 0248-1294
10. Genetic Resources and Crop Evolution 0925-9864
11. Horticultural Plant Journal 2488-0141
12. Horticulture Environment and Biotechnology 2211-3452
13. Hort. Science 0018-5345
14. Indian Horticulture Journal 2249-6823
15. Indian Journal of Arid Horticulture Naas-1234
16. Indian Journal of Dryland Agricultural Research and Development 0971-2062
17. Indian Journal of Horticulture 0972-8538
18. International Journal of Fruit Science 1553-8621
19. International Journal of Horticulture 1927-5803
20. International Journal of Innovative Horticulture 2320-0286
21. Journal of Applied Horticulture 0972-1045
22. Journal of Horticultural Research 2300-5009
23. Journal of Horticultural Science and Biotechnology 1462-0316 (Journal of Horticultural Science, England)
24. Journal of Horticultural Sciences 0973-354X
25. Journal of Horticulture 2376-0354
26. Journal of The American Society for Horticultural Science 0003-1062
27. Journal of Tree Fruit Production 1055-1387
28. New Zealand Journal of Crop and Horticultural Science 0114-0671
29. Progressive Horticulture 0970-3020
30. Scientia Horticulturae 0304-4238
31. The Asian Journal of Horticulture 0973-4767
32. The Journal of American Pomological Society 1527-3741

COURSE AND CREDIT REQUIREMENTS

Courses	Masters' Programme
(i) Course work	
Major Courses	20
Minor Courses	08
Supporting Course(s)	06
Common compulsory courses	05
Seminar	01
(ii) Comprehensive Exam	-
(iii) Thesis/ Research	30
Total	**70**

CREDIT LAYOUT FOR M.Sc. (HORTICULTURE) FRUIT SCIENCE

Semester	Major	Minor	Supporting	Seminar	Total	NCCC
I	**9**	**5**	**3**	**-**	**17**	**2**
II	**8**	**3**	**3**	**-**	**14**	**2**
III	**3**	**-**	**-**	**-**	**3**	**1**
IV	**-**	**-**	**-**	**1**	**1**	**-**
Total	**20**	**8**	**6**	**1**	**35**	**5**

M.Sc. (Hort.) FRUIT SCIENCE COURSE STRUCTURE

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

Course Code	Course Title	Credit Hours
	Major Courses (20 Credits)	**20**
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.**

SEMESTER WISE LAYOUT FOR M.Sc. (Hort.) FRUIT SCIENCE

I SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FSC 501*	Tropical Fruit Production	2+1
FSC 502*	Sub-Tropical and Temperate Fruit Production	2+1
FSC 507	Growth and Development of Fruit Crops	2+1
FSC 508	Nutrition of Fruit Crops	2+1
FSC 513	Minor Fruit Production	2+1
	Total (A)	**9**
	B) Minor courses	
BIOCHEM 501	Basic Biochemistry	3+1
PP 501	Principles of Plant Physiology-I: Plant Water Relations and Mineral Nutrition	2+1
	Total (B)	**5**
	C) Supporting Courses	
STAT 502	Statistical Methods for Applied Sciences	3+1
	Total (C)	**3**
	Total (A+B+C)	**17**
	D) Non Credit Courses	
PGS 501	Library and Information Services	0+1
PGS 504	Basic Concept of Laboratory Techniques	0+1
	Total (D)	**2**
	Total (A+B+C+D)	**17+2=19**

***Compulsory major courses**

Note: One course should be selected from non compulsory major course.

II SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
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
	Total (A)	**8**
	B) Minor courses	
GPB 502	Principles of Plant Breeding	2+1
	Total (B)	**3**
	C) Supporting Courses	
STAT 511	Experimental Designs	2+1
	Total (C)	**3**
	Total (A+B+C)	**14**
	D) Non Credit Courses	
PGS 502	Technical Writing and Communication Skill	0+1
PGS 503	Intellectual Property and its Management in Agriculture	1+0
	Total (D)	**2**
	Total (A+B+C+D)	**14+2=16**

***Compulsory major courses**

Note: One course should be selected from non compulsory major course.

III SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
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 599	**Research**	**0+30**
	Total (A)	**3**
	B) Minor courses	**NIL**
	C) Supporting Courses	**NIL**
	D) Non Credit Courses	
PGS 505	Agricultural Research, Research Ethics and Rural Development Programme	1+0
PGS-506	Disaster Management	1+0
	Total (D)	**1**
	Total	**3+1= 4**

Note: One course (minimum more than 2 credits) should be selected from non compulsory major course.

IV SEMESTER

Course No	Course Title	Credit Hours
FSC 591	Seminar	0+1
	Total	**1**
	Total	**40**
FSC 599	Research	0+30 /0+25
FSC 598	Internship / in-plant training and report writing (IDEA)	**0+ 5=5**
	Grand Total	**40+30= 70**

CREDIT LAYOUT FOR Ph.D. (HORTICULTURE) FRUIT SCIENCE

Semester	Major	Minor	Supporting	Seminar	Total	NCCC
I	6	3	3	-	12	2
II	3	3	2	-	8	2
III	3	-	-	1	4	1
IV	-	-	-	1	1	-
Total	12	6	5	2	25	5

Ph.D. (Hort.) FRUIT SCIENCE COURSE STRUCTURE

Course title with Credit load Ph.D. (Hort.) in Fruit Science

Course Code	Course Title	Credit Hours
	Major Courses (12 Credits)	**12**
FSC 601*	Innovative Approaches in Fruit Breeding	3+0
FSC 602*	Modern Trends in Fruit Production	3+0
FSC 603	Recent Developments in Growth Regulation	3+0
FSC 604	Advanced Laboratory Techniques	1+2
FSC 605	Arid and Dry Land Fruit Production	2+0
FSC 606	Abiotic Stress Management in Fruit Crops	2+1
FSC 607	Biodiversity and Conservation of Fruit Crops	2+1
FSC 608	Smart Fruit Production	2+0
Minor Courses		**06**
Supporting Courses		**05**
Common compulsory courses		**--**
FSC 691	**Seminar-I**	**0+1**
FSC 692	**Seminar-II**	**0+1**
FSC 699	**Research**	**0+75**
Total Credits		**100**

***Compulsory among major courses**

SEMESTER WISE LAYOUT FOR Ph.D. (Hort.) FRUIT SCIENCE

I SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FSC 602*	Modern Trends in Fruit Production	3+0
FSC 603	Recent Developments in Growth Regulation	3+0
FSC 605	Arid and Dry Land Fruit Production	2+0
	Total (A)	**3+3=6**
	B) Minor courses	
BIOCHEM 603	Biochemistry Of Biotic And Abiotic Stresses	3+0
	Total (B)	**3**
	C) Supporting Courses	**3**
	Total (C)	**3**
	D) Non Credit Courses	
PGS 501	Library and Information Services	0+1
PGS 504	Basic Concept of Laboratory Techniques	0+1
	Total (D)	**2**
	Total (A+B+C)	**12**

***Compulsory course**

Note: One course should be selected from non compulsory major course.

II SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FSC 601*	Innovative Approaches in Fruit Breeding	3+0
FSC 606	Abiotic Stress Management in Fruit Crops	2+1
FSC 607	Biodiversity and Conservation of Fruit Crops	2+1
	Total (A)	**3**
	B) Minor courses	
PP 607	Physiological and Molecular Aspects of Source-sink Capacity for Enhancing Yield	3+0
	Total (B)	**3**
	C) Supporting Courses	**2**
	Total (C)	**2**
	Total (A+B+C)	**8**
	D) Non Credit Courses	
PGS 502	Technical Writing and Communication Skill	0+1
PGS 503	Intellectual Property and its Management in Agriculture	1+0
	Total (D)	**2**
	Total (A+B+C)	**8**

***Compulsory course**

Note: One course should be selected from non compulsory major course.

III SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FSC 604	Advanced Laboratory Techniques	1+2
FSC 608	Smart Fruit Production	2+0
FSC 691	Seminar-I	0+1
	Total (A)	**3+1=4**
	B) Minor courses	**NIL**
	C) Supporting Courses	**NIL**
	D) Non Credit Courses	
PGS 505	Agricultural Research, Research Ethics and Rural Development Programme	1+0
	Total (D)	**1**
	Total (A+B+C)	**4**

Note: One course may be selected from non compulsory courses except seminar.

IV SEMESTER

Course No	Course Title	Credit Hours
FSC 692	Seminar II	0+1
FSC-699	Research	(0+75)
	Total	**1**

V SEMESTER

Course No	Course Title	Credit Hours
FSC-699	Research	(0+75)

VI SEMESTER

Course No	Course Title	Credit Hours
FSC-699	Research	(0+75)
	Grand Total	**25+75=100**

Restructured and Revised Syllabus

Horticultural Sciences

M.Sc. & Ph. D. (Horticulture)

in

Vegetable Sciences

Submitted by

Broad Subject Coordinator
Associate Dean
College of Agriculture,
Dr. PDKV, Akola

Discipline Coordinator
Prof. of Horticulture,
Department of Horticulture, PGI,
MPKV, Rahuri

CONTENT

1. Preamble:

Vegetables are important constituents of Indian diet and play an important role ensuring nutritional security. They are generally of short duration, high yielding, nutraceuticals rich, economically viable and generation substantial on-farm and off-farm employment. Vegetables have a pristine place in Indian agricultural economy. The country is being blessed with diverse agro-climatic conditions ranged from the temperate to arid more than 60 cultivated and 30 lesser known vegetables are being grown.

The country has witnessed a tremendous growth in vegetable production and productivity as a result of improved varieties/F1 hybrids /technologies through systematic research coupled with their large scale adoption by the farmers and developmental policies of government compared to area (2.84 m ha), production (16.5 mt) and productivity (5.8 t/ha) in1950-51 there had been phenomenal increase in area (>3 folds; 10.1 m ha), production (>10folds; 185 mt) and productivity (>3 folds; 18.0 t/ha) during 2017-18. Increasing per capita income, health consciousness, urbanization, shifting of farmers to high value vegetables due to higher income, favourable income elasticity of demand and annual growth rate of domestic demand for vegetables are also important factors fueling its growth in the country.

During 2016-17, the total exports including potato and onion accounted for Rs. 5922crores sharing 35 per cent of total horticultural exports. With the current level of vegetable production in the country (171 mt), population (1.3 billion) and considering 25 percent postharvest losses and 5 percent export and processing, the per capita availability o vegetable production in our country is 250 g as against 300 g recommended dietary allowance (RDA). With projected population of 1.45 billion by 2030, India has to produce210 mt of vegetables. The targeted production needs to be achieved through utilizing scientific technological and traditional strength in a sustainable manner without much increasing area under vegetables.

Looking in to the above scenario in vegetable production, there is a need to update the knowledge among the postgraduates of Vegetable Science. An effort is therefore made to encompass the advances made in the vegetable production by revising the post graduate curriculum for delivering and assuring quality education. The proposed curriculum aims to develop a competent human resource equipped with holistic and updated knowledge and skill in the field of Vegetable Science.

The course curriculum has been restructured to cover the current requirement of vegetable production and post harvest management to increase capabilities of students. In order to accomplish the task, either new courses have been formulated or existing course contents are upgraded to include latest developments in vegetables production. In line with national policies, the existing course contents have been upgraded and five new courses viz., Principles of vegetable breeding, Breeding for special traits in vegetable crops, Biodiversity and conservation of vegetable crops, Biotechnological approaches in vegetable crops and Advanced laboratory techniques for vegetable crops have been added.

A course on Vegetable Breeding has been divided into two courses one for selfpollinated crops and another for cross pollinated vegetable crops. New components *viz*., hydroponics, aeroponics, grafting technique and precision farming have been added inappropriate courses. The overall up-gradation of course contents as well as addition of courses are in line with national policy priorities like doubling of famer's income, more crops perdrop, jaiveek krushi, soil health, skill development, entrepreneurship development, startup initiatives, etc.

Committee of Broad Subject Coordinators and Discipline Coordinators for finalizing the PG Degrees Syllabi in the Maharashtra SAUs as per the ICAR-NCG-BSMA recommendations.

BSMA Broad Subject	ICAR-BSMA Approved Disciplines	Degree Programmes		Broad Subject Coordinator (Chairman of all Disciplines' Sub-Committees)	Discipline Coordinator (Secretary of respective Discipline Sub-Committee)
Horticultural Sciences	Vegetable Science	M. Sc. (Hort.)	Ph. D. (Hort.)	Dr. P. K. Nagre Associate Dean, College of Agriculture, Dr. PDKV, Akola E-mail: pk.nagre1@gmail.com Mobile: 9028296172	Dr. B. B. Dhakare Prof. of Horticulture, Dept. of Horticulture, PGI, MPKV, Rahuri E-mail: bhagwandhakare64@gmail.com Mobile: 9822838647

Committee for finalization of new syllabi 2022 for PG in Vegetable Science at Discipline Coordinator level

Sr. No.	Name of Faculty	Designation	Contact Number	Remarks
1.	Dr. B. B. Dhakare	Professor of Horticulture, PGI, Department of Horticulture, MPKV, Rahuri	9822838647 9420865967	Coordinator
2.	Dr. R. G. Khandekar	Professor of Horticulture & Head, Vegetable Science, College of Horticulture, Dapoli	9423048591	Member
3.	Dr. A. M. Sonkamble	Professor and Head, Department of Vegetable Science, Dr. PDKV, Akola	9657725857	Member
4.	Dr. V. S. Khandare	Professor and Sr. Research Officer (Veg.), Hort. Research Station Sub Campus MAU, Parbhani- 431 402	9422851888	Member
5.	Dr. M. N. Bhalekar	Professor and Sr. Vegetable Breeder, AICRP on Vegetable Crops, MPKV, Rahuri	9850892782	Member
6.	Dr. P. B. Sanap	Veg. Specialist I/c Veg. Unit Veg. Imp. Scheme, CES, Wakawali, Dapoli	9404100156	Member
7.	Dr. R. P. Gajbhiye	I/c-Professor, Horticulture Section, College of Agriculture, Nagpur (M. S.)	8530452381	Member
8.	Dr. V. S. Jagtap	I/c-Professor, Department of Horticulture, College of Agriculture, Latur (M. S.)	9422657460 9518997674	Member
9.	Dr. S. S. Dhumal	I/c-Professor, Horticulture Section, RCM College of Agriculture, Kolhapur	7588695507	Member
10.	Prof. Y. L. Jagdale	Subject Matter Specialist and I/c –Center for Excellence of Vegetables (Indo-Dutch Project), KVK, Baramati	9623384287	Member

11.	Dr. D. B. Kshirsagar	Associate Professor of Horticulture, PGI, Department of Horticulture, MPKV, Rahuri	9403189364	Member Secretary

For finalization of PG Vegetable Science syllabus meetings were held online mode (on dated 08.04.2022, 12.04.2022, 22.04.2022, 19.08.2022,) and two physical meetingswere conducted on dated 27.04.2022 and 22.08.2022

Dr. B. B. Dhakare
Discipline Coordinator
&
Professor of Horticulture
MPKV., Rahuri

Dr. P. K. Nagre
Broad Subject Coordinator
&
Associate Dean, College of Agriculture,
Dr. PDKV, Akola.

Implementation of New Curriculum

The universities offering PG programmes in Horticultural sciences (Vegetable Science) need to be supported for establishing specialized laboratories equipped with state-of-the-art equipment's for conducting practical classes. A one-time catch-up grant should be awarded to each SAU, offering PG programmes in Vegetable Science to meet the expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. To execute the new PG programmes in Vegetable Science in an effective manner, special funds from ICAR would be required for the outsourcing of faculty from Indian/Foreign Universities for some initial years.

Expected Outcome

- Revamping of post graduate programme in whole of Vegetable Science throughout the country.
- Imparting quality education.
- Development of technical manpower to cater the need of governments, corporate sector and research organization in India and abroad. Exposure to the faculty in the latest technical knows.

3. Organization of Course Contents & Credit Requirements

3.1. Minimum Residential Requirement:

M. Sc. : 4 Semesters

Ph. D. : 6 Semesters

3.2. Name of the Departments / Divisions

Vegetable Science

1.3. Nomenclature of Degree Programme

M.Sc.(Hort.) in Vegetable Science

Ph. D. (Hort.) in Vegetable Science

1.4. Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by Code No. 591, and two Seminars for Doctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series
- Master's Research: 599 and Doctoral Research: 699

3.5. Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is provided at the end which may be useful as study material for 600/700 series courses as well as research topics.
- Lecture schedule and practical schedule has also be given at the end of each course to facilitate the teacher to complete the course in an effective manner.

3.6. Eligibility of Admission

Master's Degree Programme

B. Sc. Horticulture / B. Sc. (Hons.) Horticulture. B. Sc. Agri. / B. Sc. (Hons.) Agriculture / B. Sc. Forestry/ B. Sc. (Hons.) Forestry, or equivalent degree with four years duration of agriculture and related Universities and having the common entrance test in Horticulture conducted by competent authority.

Doctoral Degree Programme

Master Degree in the concerned Department/Discipline M. Sc. (Hort.) in Vegetable Science and having appearing the Common Entrance Test conducted by competent authority.

4. Credit Requirements

Course Details	**Masters Degree**	**Doctoral Degree**
Major Courses	20	12
Minor Courses	08	06
Supporting / Optional	06	05
Common PGS Courses	05	-
Seminar	01	02
Research	30	75
Total	**70**	**100**

5. M.Sc. (Hort.) Vegetable Science Course Structure

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	2+1
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 PGS courses		**05**
VSC 591	Master Seminar	0+1
VSC 599	**Research**	**0+30**
	Total Credits	**70**

***Compulsory among major courses**

Common PGS Courses: (Non Credit)

Course code	Course Title	Credits
PGS 501	Library and Information Services	0+1
PGS 502	Technical Writing and Communications Skills	0+1
PGS 503	Intellectual Property and its management in Agriculture	1+0
PGS 504	Basic Concepts in Laboratory Techniques	0+1
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
PGS 506	Disaster Management	1+0

Minor Disciplines: Suggestive list of discipline for minor courses

1. Genetics and Plant Breeding
2. Seed Science and Technology
3. Plant Physiology
4. Fruit Science
5. Agronomy
6. Agricultural Statistics
7. Biochemistry
8. Soil Science
9. Floriculture and Landscaping
10. Plantation, Spices, Medicinal and Aromatic Crops
11. Post-harvest Management

Note: These are the minor disciplines for M.Sc. Students; however some suggestive minor courses included in semester wise layout.

Minor Courses- Suggestive list of minor courses

Course Code	Course title	Credit hours
BIOCHEM 501	Basic Biochemistry	3+1
GPB 506	Molecular Breeding and Bioinformatics	2+1
PP 502	Principles of Plant Physiology-II: Metabolic Processes and Growth Regulation	2+1
AGRON 502	Principles and Practices of Soil Fertility and Nutrient Management	2+1
AGRON 503	Principles and Practices of Weed Management	2+1
AGRON 504	Principles and Practices of Water Management	2+1
SOIL 502	Soil fertility and fertilizer use	2+1

Supporting/Optional Courses:

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Statistic
2. Agronomy
3. Soil Science
4. Biochemistry
5. Organic Farming
6. Forestry
7. Plant Pathology
8. Plant Physiology
9. Entomology
10. Computer Science and Information Technology

Supporting Courses- Suggestive list of Supporting Courses

Course Code	Course Title	Credit Hours
STAT 502	Statistical Methods for Applied Sciences	3+1
STAT 511	Experimental Designs	2+1
STAT 522	Data Analysis Using Statistical Packages	2+1
MCA 511	Introduction to Communication Technologies, Computer Networking and Internet	1+1
MCA 512	Information Technology in Agriculture	1+1
BIOCHEM 505	Techniques in Biochemistry	2+2

Compulsory Non Credit Deficiency Courses:

Those students who are non B. Sc. (Agri.)/ B. Sc. (Hons.) Agriculture/ B. Sc. (Hort.)/ B. Sc. (Hons.) Horticulture or equivalent degree with four years duration of agriculture-related Universities

Course No.	Course Title	Credit Hours
VSC 421	Potato and Tuber Crops	1+1=2
VSC 432	Tropical and Subtropical Vegetable crops	2+1=3
VSC 443	Spices and Condiments	2+1=3
VSC 444	Precision Farming and Protected Cultivation	2+1=3
VSC 445	Temperate Vegetable crops	1+1=2

VSC 456	Breeding of Vegetables, Tuber and Spice Crops	2+1=3
VSC 467	Seed Production of Vegetable Tuber and Spice Crops	2+1=3

Note: Students from Non Horticulture stream will be required to complete Non credit deficiency courses (6 to 10 credits) from the above courses as decided by the Student Advisory committee.

CREDIT LAYOUT FOR M. Sc. (HORTICULTURE)
VEGETABLE SCIENCE

Semester	Major	Minor	Supporting	Seminar	Total	CCC
I	9	7	4	-	**20**	2
II	8	3	3	-	**14**	2
III	3	-	-	-	**3**	2
IV	-	-	-	1	**1**	-
Total	**20**	**10**	**7**	**1**	**38**	**6**

1. **Ph. D. (Hort.) in Vegetable Science Course Structure**

Course Code	Course title	Credit hours
Major Courses (12 Credits)		
VSC 601*	Recent Trends in Vegetable Production	3+0
VSC 602*	Advances in Breeding of Vegetable Crops	3+0
VSC 603	Abiotic Stress Management in Vegetable Crops	2+1
VSC 604	Seed Certification, Processing and Storage of Vegetable Crops	2+1
VSC 605	Breeding for Special Traits in Vegetable Crops	2+0
VSC 606	Biodiversity and Conservation of Vegetable Crops	2+1
VSC 607	Biotechnological Approaches in Vegetable Crops	2+1
VSC 608	Advanced Laboratory Techniques for Vegetable Crops	1+2
Minor Courses		**06**
Supporting Courses		**05**
Common compulsory courses		**--**
VSC 691	Doctoral Seminar I	0+1
VSC 692	Doctoral Seminar II	0+1
VSC 699	Research	0+75
	Total Credits	**100**

***Compulsory among major courses**

Minor Disciplines: Suggestive list of minor discipline

2. Genetics and Plant Breeding
3. Plant Physiology
4. Fruit Science
5. Agronomy
6. Agricultural Statistics
7. Biochemistry
8. Soil Science

Note: These are the minor disciplines for Ph.D. Students; however some suggestive minor courses included in semester wise layout.

Minor Courses: Suggestive list of minor courses

Code	Course title	Credit hours
GPB 602	Advances in Biometrical Genetics	2+1
FSC 603	Recent Developments in Growth Regulation	3+0
MBB 601	Plant Molecular Biology	3+0
PP 607	Physiological and Molecular Aspects of Source-sink Capacity for Enhancing Yield	3+0

Supporting Discipline: Suggestive list of supporting Discipline

1. Agronomy
2. Soil Science
3. Agricultural Economics and Agricultural Statistics
4. Biochemistry and Microbiology
5. Genetics and Plant Breeding (GPB)
6. Plant Physiology
7. Molecular Biology and Biotechnology

Supporting Courses: Suggestive list of supporting courses

Course Code	Course Title	Credit Hours
AGRON 604	Recent trends in Weed Management	2+0
STAT 601	Advanced Data Analytics	1+2
STAT 604	Advanced Statistical Methods	2+1
MBB 602	Plant Genome Engineering	3+0
SOIL 603	Physical chemistry of soil	2+0
MICRO 601	Improvement in fermentation Technology	2+1

Note: Student Advisory committee may select the supporting courses from above listed disciplines however, some courses are suggested.

9. COURSE CONTENT OF MASTER DEGREEE

Course Title : PRODUCTION OF COOL SEASON VEGETABLE CROPS (2+1)

Course Code : VSC 501

Credit hours : (2+1)

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, hydroponics 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 and value addition, 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, knolkhol, 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- Indian spinach, beet leaf, fenugreek, coriander and lettuce

PRACTICAL

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

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
	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, hydroponics 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 and value addition, pest and disease management and production economics of crops.	
Unit – I - Bulb and tuber crops		
1-2	Potato	10
3-5	Onion	10
5-6	Garlic	05
Unit – II- Cole crops		
7-8	Cabbage	15
9-10	Cauliflower	
11-13	Knol-khol, Sprouting broccoli	05
14-16	Brussels Sprout and Kale	05
Unit –III- Root crops		
17-18	Carrot	05
19	Radish	05
20	Turnip	05
21	Beet root	05
Unit –IV- Peas and beans		
22-23	Garden pea	10
24-25	Broad bean	05
Unit –V- Leafy vegetables		
26-27	Indian spinach (Palak)	05

28	Beet leaf	
29	Fenugreek	05
30	Coriander	
31	Lettuce	05

PRACTICAL

Practical No.	Topic
1	Scientific raising of nursery and seed treatment.
2-3	Sowing and transplanting.
4-5	Description of commercial varieties and hybrids.
6	Demonstration on methods of irrigation, fertilizers and micronutrients application.
7	Mulching practices and weed management.
8-9	Use of plant growth substances in cool season vegetable crops.
10	Study of nutritional and physiological disorders.
11	Studies on hydroponics, aeroponics and other soilless culture.
12	Identification of important pest and diseases and their control.
13	Preparation of cropping scheme for commercial farms.
14	Visit to commercial farm, greenhouse/polyhouses.
15	Visit to vegetable market.
16	Analysis of benefit to cost ratio.

RESOURCES

Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G., 2003. Vegetablecrops. Vols. I-III. Naya udyog.

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Singh, D.K., 2007, Modern vegetable varieties and production technology. International bookdistributing Co.

Singh, S.P. (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, H.C. and Kelly, W.C. (Eds.), 1978, Vegetable crops. Tata McGraw-Hill.

Course Title : PRODUCTION OF WARM SEASON VEGETABLE CROPS (2+1)

Course Code : VSC 502

Credit hours : (2+1)

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 and value addition, 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 other yams

Unit V : Leafy and perennial vegetables-Amaranths, drumstick and sesbania (*Hadga*)

PRACTICAL

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

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
	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 and value addition, pest and disease management and economics of crops.	
Unit I - Fruit vegetables		
1-2	Tomato	10
3-4	Brinjal	10
5-7	Hot pepper and sweet pepper	10
8-9	Okra	05
Unit II-Beans		
10-12	French bean and Indian bean (Sem),	15
13-15	Cluster bean and cowpea	
UnitIII-Cucurbits		
16-17	Cucumber	15
18-20	Watermelon, muskmelon and snapmelon	
21-24	Gourds-Bottle gourd, bitter gourd, ridge gourd and smooth gourd	15
25-26	Pumpkin and squashes	
Unit IV-Tuber crops		
27-28	Sweet potato and tapioca	15
29-30	Elephant foot yam, taro and other yams	
Unit V-Leafy and perennial vegetables		
31	Amaranths	05
32	Drumstick and sesbania (*Hadga*)	

PRACTICALS

Practical No.	Topic
1	Scientific raising of nursery and seed treatments
2	Sowing, transplanting and vegetable grafting
3	Description of commercial varieties and hybrids in warm season vegetable crops
4	Demonstration on methods of irrigation, fertilizers and micronutrients application
5-6	Mulching practices and weed management in warm season vegetable crops
7	Use of plant growth substances in warm season vegetable crops
8-9	Study of nutritional and physiological disorders
10	Studies on hydroponics, aeroponics and other soilless culture
11-12	Identification of important pest and diseases and their control
13	Preparation of cropping scheme for commercial farms
14	Visit to commercial farm and greenhouse/poly-houses
15	Visit to vegetable markets
16	Analysis of benefit to cost ratio

RESOURCES

Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G., 2003, Vegetablecrops. Vols. I-III. Naya udyog.

Bose, T.K., Som, M.G. and Kabir, J. (Eds.), 1993, Vegetable crops. Naya prokash.

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

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Course Title : GROWTH AND DEVELOPMENT OF VEGETABLE CROPS

Course Code : VSC 503

Credit hours : (2+1)

THEORY

Unit I : Introduction and phytohormones- Definition of growth and development; Cellular structures and their functions; Physiology of phytohormones 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, gibberellins, 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.

PRACTICAL

1. Preparation of plant growth regulator's solutions and their application
2. Experiments in breaking and induction of dormancy by chemicals
3. Induction of parthenocarpy and fruit ripening
4. 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
5. Growth analysis techniques in vegetable crops
6. Grafting techniques in tomato, brinjal, cucumber and sweet pepper

TEACHING SCHEDULE

THEORY

Periods	Topic	Weightage (%)
Unit I-Introduction and phytohormones		
1-2	Definition of growth and development; Cellular structures and their functions.	10
3-4	Physiology of phytohormones functioning/biosynthesis and mode of action; Growth analysis and its importance in vegetable production.	10
Unit II-Physiology of dormancy and germination		
5-7	Physiology of dormancy and germination of vegetable seeds, tubers and bulbs;	05
8-11	Role of auxins, gibberellins, cyktokinins and abscissic acid; Application of synthetic PGRs including plant growth retardants and inhibitors for various purposes in vegetable crops;	10
12-14	Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production.	05
Unit III- Abiotic factors		
15-16	Impact of light, temperature, photoperiod, carbon dioxide, oxygen and other gases on growth, development of underground parts.	10
17-18	Flowering and sex expression in vegetable crops and apical dominance.	10
Unit IV-Fruit physiology		
19-21	Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops.	10
22-25	Phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening.	10
Unit V- Morphogenesis and tissue culture		
26-27	Morphogenesis in vegetable crops.	05
28-30	Tissue culture techniques in vegetable crops	05
31-32	Grafting techniques in different in vegetable crops	10

PRACTICALS

Periods	Topic
1-2	Preparation of plant growth regulator's solutions and their application.
3-4	Experiments in breaking and induction of dormancy by chemicals.
5-6	Induction of parthenocarpy and fruit ripening.
7-9	Application of plant growth substances for improving flower initiation, changing sex expression in cucurbits.
10-11	Checking flower and fruit drops and improving fruit set in Solanaceous vegetables.
12-13	Growth analysis techniques in vegetable crops.
14-16	Grafting techniques in tomato, brinjal, cucumber and sweet pepper.

RESOURCES

Bleasdale, J.K.A., 1984, Plant physiology in relation to horticulture (2nd Edition) MacMillan.

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Course Title : PRINCIPLES OF VEGETABLE BREEDING

Course Code : VSC 504

Credit hours : (2+1)

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 stresses (diseases, insect pests and nematode), abiotic stresses (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, PPV and FR Act.

PRACTICAL

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

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
Unit I- Importance and history		
1-3	Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding	10
Unit II-Selection procedures		
4-8	Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture	20
9-12	Breeding for biotic stress (diseases, insect pests and nematode), abiotic stress (temperature, moisture and salt)resistance and quality improvement	10
13-14	Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE)	05
Unit III- Heterosis breeding		
15-18	Heterosis breeding- Types, mechanisms and basis of heterosis.	10
19-22	Facilitating mechanisms like male sterility, self-incompatibility and sex forms.	10
Unit IV- Mutation and Polyploidy breeding		
23-26	Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.	15
Unit V- Ideotype breeding		
27-29	Ideotype breeding; varietal release procedure; DUS testing in vegetable crops.	10
30-32	Application of in-vitro and molecular techniques in vegetable improvement, PPV and FR Act.	10

PRACTICAL

Practical No.	Topics
1-3	Floral biology and pollination behaviour of different vegetables.
4-5	Techniques of selfing and crossing of cole crops (Cabbage cauliflower, knolkhol and brussels sprout).
6-8	Techniques of selfing and crossing of cucurbits (Watermelon, muskmelon, gourds pumpkin and squashes).
9-11	Techniques of selfing and crossing of different fruit vegetables (Tomato, eggplant, hot pepper and okra).
12-13	Breeding system and handling of filial generations of different vegetables
14-15	Exposure to biotechnological lab practices.
16	Visit to breeding farms.

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Allard, R.W., 1960, Principle of plant breeding. John Willey and Sons, USA.

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Singh, Ram J., 2007, Genetic resources, chromosome engineering, and crop improvement vegetable crops(Vol. 3). CRC Press, Fl, USA.

Course Title : BREEDING OF SELF POLLINATED VEGETABLE CROPS

Course Code : VSC 505

Credit hours : (2+1)

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, lima bean and broad bean
Unit V	:	Leafy vegetables- Lettuce and fenugreek

PRACTICAL

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

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage(%)
1-6 (General)	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.	15
Unit I –Tuber crops		
7-9	Potato	10
Unit II -Fruit vegetables		
10-14	Tomato and brinjal (egg plant)	15
15-17	Hot pepper and sweet pepper	10
18-19	Okra	10
Unit III -Leguminous vegetables		
20-22	Garden peas and cowpea	10
Unit IV -Leguminous vegetables		
23-26	French bean and Indian bean	10
27-29	Cluster bean, lima bean and broad bean	10
Unit-V - Leafy vegetables		
30-32	Lettuce and fenugreek	10

PRACTICAL

Practical No.	Topics
1	Floral mechanisms favouring self and often cross pollination.
2-3	Progeny testing and development of inbred lines.
4	Selection of desirable plants from breeding population.
5-6	Observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations.
7	Palynological studies, selfing and crossing techniques.
8-9	Hybrid seed production of vegetable crops in bulk.
10-11	Screening techniques for biotic and abiotic stress resistance in above mentioned crops.
12-14	Molecular marker techniques to identify useful traits in vegetable crops and special breeding techniques.
15	Methods of induction of polyploidy.
16	Visit to breeding farms.

RESOURCES

Allard, R.W., 1999, Principles of plant breeding. John Wiley and Sons.

Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.

Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J., 2005, Plant genetic resources:horticultural crops. Narosa Publ. House.

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Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.), 1993, Plant Breeding-principlesand prospects. Chapman and Hall.

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Kumar, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops.Agro Botanical Publ.

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Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2004, Hybrid vegetable development.International Book Distributing Co.

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

Course Title : BREEDING OF CROSS POLLINATED VEGETABLE CROPS

Course Code : VSC 506

Credit hours : (2+1)

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, knolkhol, broccoli and brussels sprouts
Unit III	:	Root and bulb crops- Carrot, radish, turnip, beet root, garlic and onion
Unit IV	:	Tuber crops- Sweet potato, tapioca, aroids and yams
Unit V	:	Leafy vegetables- Beet leaf, spinach, amaranth and coriander

PRACTICAL

1. Floral mechanisms favouring cross pollination
2. Development of inbred lines
3. Selection of desirable plants from breeding population
4. Observations and analysis of various quantitative and qualitative traits in germplasm, hybrids and segregating generations
5. Induction of flowering, palynological studies, selfing and crossing techniques
6. Hybrid seed production of vegetable crops in bulk; Screening techniques for bioticand abiotic stress resistance in above mentioned crops
7. Demonstration of sib-mating and mixed population
8. Molecular marker techniques to identify useful traits in vegetable crops and special breeding techniques
9. Visit to breeding blocks

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage(%)
	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		
1-5	Gourds-Bottle gourd, bitter gourd, ridge gourd and sponge gourd	10
6-9	Watermelon, muskmelon and cucumber	10
10-11	Pumpkin and squashes	05
Unit II - Cole crops		
12-15	Cauliflower and cabbage	10
16-17	Knolkhol, broccoli and brussels sprouts	10
Unit III - Root and bulb crops		
18-19	Carrot and radish	10
20-21	Turnip and beet root	
22-23	Onion	10
24	Garlic	05
Unit IV - Tuber crops		
25-26	Sweet potato and tapioca	10
27-28	Aroids and yams	05
Unit-V - Leafy vegetables		
29-30	Beet leaf and spinach	15
31-32	Amaranths and coriander	

PRACTICAL

Practical No.	Topics
1	Floral mechanisms favouring cross pollination.
2-3	Progeny testing and development of inbred lines.
4	Selection of desirable plants from breeding population.
5-6	Observations and analysis of various quantitative and qualitative traits in germplasm, hybrids and segregating generations.
7	Induction of flowering, palynological studies, selfing and crossing techniques.
8-9	Hybrid seed production of vegetable crops in bulk.
10-11	Screening techniques for biotic and abiotic stress resistance in cross pollinated vegetable crops.
12-13	Demonstration of sib-mating and mixed population.
14-15	Molecular marker techniques to identify useful traits in vegetable crops and special breeding techniques.
16	Visit to breeding blocks.

RESOURCES

Allard, R.W., 1999, Principles of plant breeding. John Wiley and Sons.

Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.

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Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2004, Hybrid vegetable development. International book distributing Co.

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

Course Title : PROTECTED CULTIVATION OF VEGETABLE CROPS

Course Code : VSC 507

Credit hours : (2+1)

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

PRACTICAL

1. Study of various types of protected structure
2. Study of different methods to control temperature, carbon dioxide and light
3. Study of different types of growing media, training and pruning systems in greenhouse crops
4. Study of fertigation and nutrient management under protected structures
5. Study of insect pests and diseases in greenhouse and its control
6. Use of protected structures in hybrid seed production of vegetables
7. Economics of protected cultivation (Any one crop)
8. Visit to established green/ polyhouses /shade net houses in the region

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
Unit I- Scope and importance		
1-2	Scope and importance- Concept, scope and importance of protected cultivation of vegetable crops.	15
3-5	Principles, design, orientation of structure, low and high cost poly-houses /greenhouse structures	
Unit II- Types of protected structure		
6-10	Classification and types of protected structures greenhouse/ poly-houses, 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.	15
11-12	Soil and soilless media for bed preparation	05
13-14	Design and installation of drip irrigation and fertigation system	
Unit III- Abiotic factors		
15-17	Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity, etc. on growth and yield of different vegetables.	15
Unit IV- Nursery raising		
18-20	High tech vegetable nursery raising in protected structures using plugs and portrays, different media for growing nursery under protected cultivation.	10
21-22	Nursery problems and management technologies including fertigation	05
Unit V- Cultivation of crops		
23-24	Regulation of flowering and fruiting in vegetable crops.	05
25-28	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.	15
Unit VI- Solutions to problems		
29-30	Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures.	10

31	Use of protected structures for seed production	05
32	Economics of greenhouse crop production	

PRACTICALS

Practical No.	Topic
1-2	Study of various types of protected structure.
3-4	Study of different methods to control temperature, carbon dioxide and light.
5	Study of different types of growing media.
6-7	Study of training and pruning systems in green house crops.
8-9	Study of fertigation and nutrient management under protected structures.
10-11	Study of insect pests and diseases in greenhouse and its control.
12-13	Use of protected structures in hybrid seed production of vegetables.
14	Economics of protected cultivation (Any one crop).
15-16	Visit to established green/polyhouse/ shade net house in the region.

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Chadha, K.L. and Kalloo, G. (Eds.), 1993-94, Advances in horticulture. Malhotra Pub. House.

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Singh, S., Singh, B. and Sabir, N., 2014, Advances in protected cultivation. New India publishing agency, New Delhi.

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Course Title : SEED PRODUCTION OF VEGETABLE CROPS

Course Code : VSC 508

Credit hours : (2+1)

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

Unit II : 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

PRACTICAL

1. Study of floral biology and pollination mechanisms in vegetables
2. Determination of modes of pollination
3. Field and seed standards
4. Use of pollination control mechanisms in hybrid seed production of important vegetables
5. Maturity standards and seed extraction methods
6. Seed sampling and testing
7. Visit to commercial seed production areas
8. Visit to seed processing plant
9. Visit to seed testing laboratories

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
Unit I- Introduction, history, propagation and reproduction		
1-2	Introduction, definition of seed and its quality, seed morphology, development and maturation.	15
3-5	Apomixis and fertilization; Modes of propagation and reproductive behaviour; Pollination mechanisms and sex forms in vegetables	
6	History of vegetable seed production; Status and share of vegetable seeds in seed industry	
Unit II- Agro-climate and methods of seed production		
7-8	Agro-climate and its influence on quality seed production.	10
9-10	Deterioration of crop varieties, genetical and agronomic principles of vegetable seed production.	
11-12	Methods of seed production, hybrid seeds and techniques of large scale hybrid seed production and seed village concept	10
Unit III- Seed multiplication and its quality maintenance		
13-16	Seed multiplication ratios and replacement rates in vegetables; Generation system of seed multiplication.	20
	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		
17-19	Maturity standards; seed harvesting, curing and extraction.	10
20-21	Seed processing viz., cleaning, drying and treatment of seeds, seed health and quality enhancement, packaging and marketing.	05
22-23	Principles of seed storage; Orthodox and recalcitrant seeds; Seed dormancy.	05

Unit V- Improved agro-techniques and field and seed standards		
24-25	Field and seed standards in important Solanaceous, Leguminous and Cucurbitaceous vegetables.	05
26-28	Field and seed standards in important cole crops, leafy vegetables, bulbous and root crops and okra.	10
29-30	Clonal propagation and multiplication in vegetative propagated crops	05
31-32	Seed plot technique and true potato seed production in potato.	05

PRACTICALS

Practical No.	Topics
1-2	Study of floral biology and pollination mechanisms in important Solanaceous, Leguminous and Cucurbitaceous vegetables.
3-4	Study of floral biology and pollination mechanisms in important cole crops, leafy vegetables, bulbous and root crops and okra.
5	Determination of modes of pollination in important vegetables crops.
6-7	Field and seed standards in important Solanaceous, Leguminous and Cucurbitaceous vegetables.
8-9	Field and seed standards in important cole crops, leafy vegetables, bulbous and root crops and okra.
10	Use of pollination control mechanisms in hybrid seed production of important vegetable crops.
11	Maturity standards and seed extraction methods of important vegetable crops.
12	Seed sampling and seed testing (genetic purity, seed viability, seedling vigour, physical purity) of vegetable crops.
13	Releasing and notification procedures of vegetable varieties.
14	Visit to commercial seed production areas of vegetable crops.
15	Visit to seed processing plant of vegetable varieties crops.
16	Visit to seed testing laboratories of vegetable varieties crops.

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Course Title : PRODUCTION OF UNDERUTILIZED VEGETABLE CROPS

Course Code : VSC 509

Credit hours : (2+1)

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, round gourd, and little/Ivy gourd, snake gourd, pointed gourd, kachri, long melon, snapmelon and gherkin

Unit V : Yam and beans- Elephant foot yam, yam bean, lima bean, winged bean, tapioca, aroids and yams (Dioscorea)

PRACTICAL

1. Identification and botanical description of plants and varieties
2. Seed/planting material
3. Production, lay out and method of planting
4. Important cultural operations
5. Identification of important pests and diseases and their control
6. Maturity standards and harvesting
7. Visit to local farms

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
	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		
1-4	Asparagus, leek and chinese chive	10
UNIT II - Cole and salad crops		
5-7	Red cabbage and Chinese cabbage	10
8-10	Kale, sweet corn and baby corn	10
UNIT III- Leafy vegetables		
11-13	Celery, parsley, Indian spinach (poi) and spinach,	10
14-16	Chenopods, chekurmanis and indigenous vegetables of regional importance	10
UNIT IV- Gourds and melons		
17-20	Sweet gourd, spine gourd, round gourd, and little/Ivy gourd and snake gourd	15
21-24	Pointed gourd, kachri, long melon, snapmelon and gherkin	15
UNIT V - Yam and beans		
25-28	Elephant foot yam, yam bean, lima bean and winged bean	10
29-32	Tapioca, aroids and yams (Dioscorea)	10

PRACTICAL

Practical No.	Topics
1-3	Identification and botanical description of plants and varieties.
4-6	Seed/planting material of underutilized vegetable crops.
7-9	Production, lay out and method of planting of underutilized vegetable crops.
10-11	Important cultural operations of underutilized vegetable crops.
12-13	Identification of important pests and diseases and their control.
14-15	Maturity standards and harvesting of underutilized vegetable crops.
16	Visit to local farms of underutilized vegetable crops.

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Course Title : SYSTEMATICS OF VEGETABLE CROPS

Course Code : VSC 510

Credit hours : (1+1)

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.

PRACTICAL

1. Identification, description, classification and maintenance of vegetable species and varieties
2. Survey, collection of allied species and genera locally available
3. Preparation of keys to the species and varieties
4. Methods of preparation of herbarium and specimens

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
Unit I- Significance of systematic		
1	Significance of systematics and crop diversity in vegetable crops.	20

2	Principles of classification; different methods of classification.	
3	Salient features of international code of nomenclature of vegetable crops.	
Unit II- Origin and evolution		
4-5	Origin, history, evolution and distribution of vegetable crops	10
Unit III- Botanical and morphological description		
6-7	Botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables.	10
8-9	Morphological keys to identify important families, floral biology, floral formula and diagram.	10
10	Morphological description of all parts of vegetables.	10
Unit IV- Cytology		
11-12	Cytological level of various vegetable crops with descriptive keys.	20
Unit V- Molecular markers		
13-14	Importance of molecular markers in evolution of vegetable crops.	10
15-16	Molecular markers as an aid in characterization and taxonomy of vegetable crops.	10

PRACTICAL

Practical No.	Topics
1-3	Identification, description, classification and maintenance of vegetable species and varieties.
4-7	Survey, collection of allied species and genera locally available.
8-10	Preparation of keys to the species and varieties.
11-16	Methods of preparation of herbarium and specimens.

RESOURCES

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Vincent, E.R. and Yamaguchi, M., 1997, World vegetables. 2nd Ed. Chapman and Hall.

Course Title : ORGANIC VEGETABLE PRODUCTION

Course Code : VSC 511

Credit hours : (1+1)

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, Panchya gavvya, 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

PRACTICAL

1. Methods of preparation and use of compost, vermi-compost, biofertilizers and bio-pesticides
2. Soil solarisation; Use of green manures
3. Waste management; Organic soil amendments in organic production of vegetable crops
4. Weed, pest and disease management in organic vegetable production
5. Visit to organic fields and marketing centres

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
Unit I- Importance and principles		
1-2	Importance, principles, perspective, concepts and components of organic farming in vegetable crops	10
Unit II- Organic production of vegetables		
3-4	Organic production of Solanaceous and Cucurbitaceous vegetables.	15
5-6	Organic production of vegetable crops viz., Cole, root and tuber crops.	15
Unit III- Managing soil fertility		
7-8	Managing soil fertility, mulching, raising green manure crops, weed management in organic farming system.	10
9-10	Crop rotation in organic production; processing and quality control of organic vegetable produce.	10
Unit IV- Composting methods		
11-12	Indigenous methods of composting, Panchya gavvya, Biodynamics preparations and their application.	10
13-14	ITKs in organic vegetable farming; Role of botanicals and bio-control agents in the management of pests and diseases in vegetable crops	10
Unit V- Certification and export		
15	Techniques of natural vegetable farming.	10
16	GAP and GMP certification of organic products; export-opportunities and challenges	10

PRACTICAL

Practical No.	Topics
1-4	Methods of preparation and use of compost (NADEF), vermi-compost, biofertilizers and bio-pesticides
5	Soil solarization.
6-7	Use of green manures.
8	Waste management.
9-10	Organic soil amendments in organic production of vegetable crops.
11-12	Weed management in organic vegetable production.
13-14	Pest and disease management in organic vegetable production.
15-16	Visit to organic fields and marketing centers

RESOURCES

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Course Title : PRODUCTION OF SPICE CROPS

Course Code : VSC 512

Credit hours : (2+1)

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, postharvest management, plant protection measures, quality control and pharmaceutical significance of crops mentioned below:

Unit I	:	Fruit spices- Black pepper, small cardamom, large cardamom and vanilla
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 (kokam) and all spice.
Unit VI	:	Veg. spice - Chilli

PRACTICAL

1. Identification of seeds and plants
2. Botanical description of plant
3. Preparation of spice herbarium
4. Propagation
5. Nursery raising
6. Field layout and method of planting
7. Cultural practices
8. Harvesting, drying, storage, packaging and processing
9. Value addition
10. Short term experiments on spice crops

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage(%)
	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, postharvest management, plant protection measures, quality control and pharmaceutical significance of crops mentioned below:	
Unit I - Fruit spices		
1-2	Black pepper	20
3-5	Small cardamom and large cardamom	
6-7	Vanilla	
Unit II - Bud and kernel		
8-10	Clove	15
11-13	Nutmeg	
Unit III - Underground spices,		
14-16	Turmeric	15
17-19	Ginger and garlic	
Unit IV - Seed spices		
20-22	Coriander, fenugreek and cumin	10
23-25	Fennel, ajowain, dill and celery	10
Unit-V - Tree spices		
26-28	Cinnamon and tamarind	10
29-30	Garcinia (kokam) and all spice	10
Unit VI - Veg. spice		
31-32	Chilli	10

PRACTICAL

Practical No.	Topics
1	Identification of seeds and plants.
2-3	Botanical description of different spices crops.
4	Preparation of spice herbarium.
5-6	Propagation of different spices crops.
7	Nursery raising of different spices crops.
8-9	Field layout and method of planting of different spices crops.
10	Cultural practices in different spices crops.
11-13	Harvesting, drying, storage, packaging and processing of different spices crops.
14-15	Value addition of different spices crops.
16	Short term experiments on spice crops.

RESOURCES

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Course Title : PROCESSING OF VEGETABLE CROPS

Course Code : VSC 513

Credit hours : (1+1)

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 license; 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

PRACTICAL

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

TEACHING SCHEDULE

THEORY

Lecture No.	Topics	Weightage (%)
Unit I- Present status		
1-2	Present status and future prospects of vegetable preservation industry in India	10
Unit II- Spoilage and biochemical changes		
3	Spoilage of fresh and processed vegetable produce.	15
4-5	Biochemical changes and enzymes associated with spoilage of vegetable produce.	
6	Principal spoilage organisms, food poisoning and their control measures, Role of microorganisms in food preservation.	10
Unit III- Processing equipments		
7	Raw materials for processing and processing equipments.	15
8	Primary and minimal processing, processing equipments; Layout and establishment of processing industry	
9	FPO license; Importance of hygiene; Plant sanitation	05
Unit IV- Quality control		
10	Quality assurance and quality control, TQM, GMP. Food standards – FPO, PFA, etc. Food laws and regulations.	10
11	Food safety- hazard analysis and critical control points (HACCP). Labeling and labeling act, nutrition labeling.	10
Unit V- Value addition		
12-13	Major value added products from vegetables. Utilization of byproducts of vegetable processing industry.	15
14-15	Management of waste from processing factory. Investment analysis.	10
16	Principles and methods of sensory evaluation of fresh and processed vegetables.	

PRACTICAL

Practical No.	TOPICS
1-2	Study of machinery and equipments used in processing of vegetable produce.
3-4	Chemical analysis for nutritive value of fresh and processed vegetables.
5-6	Study of different types of spoilages in fresh as well as processed vegetable produce.
7	Classification and identification of spoilage organisms.
8-9	Study of biochemical changes and enzymes associated with spoilage.
10-11	Laboratory examination of vegetable products.
12	Sensory evaluation of fresh and processed vegetables.
13-14	Study of food standards –National, international, CODEX Alimentarius.
15-16	Visit to processing units to study the layout, equipments, hygiene, sanitation and residual / waste management.

RESOURCES

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Course Title : POSTHARVEST MANAGEMENT OF VEGETABLE CROPS

Course Code : VSC 514

Credit hours : (2+1)

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; Pre-harvest practices and other factors affecting postharvest losses

Unit IV : Packinghouse operations- Packing house operations; Commodity pretreatments chemicals, wax coating, pre-cooling 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

PRACTICAL

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

TEACHING SCHEDULE

THEORY

Lecture No.	Topics	Weightage (%)
Unit I- Importance and scope		
1-2	Importance and scope of post-harvest management of vegetables	10
Unit II- Maturity indices and biochemistry		
3-4	Maturity indices and standards for different vegetables; Methods of maturity determination.	10
5-6	Ethylene evolution and ethylene management; Respiration and transpiration along with their regulation methods.	10
7-8	Biochemistry of maturity and ripening; Enzymatic and textural changes.	10
Unit III- Harvesting and losses factors		
9	Harvesting tools and practices for specific market requirement.	05
10-11	Postharvest physical and biochemical changes; Pre-harvest practices and other factors affecting postharvest losses.	15
Unit IV- Packinghouse operations		
12	Packing house operations; commodity pretreatments chemicals, wax coating, pre-cooling and irradiation.	10
13	Packaging of vegetables, prevention from infestation, management of postharvest diseases and principles of transportation.	10
Unit V- Methods of storage		
14	Ventilated, refrigerated, modified atmosphere and controlled atmosphere storage, hypobaric storage and cold storage.	10
15	Zero-energy cool chamber.	10
16	Storage disorders like chilling injury in vegetables.	

PRACTICAL

Practical No.	TOPICS
1-2	Studies on stages and maturing indices of vegetable crops.
3-4	Ripening of commercially important vegetable crops.
5-6	Studies of harvesting, pre-cooling, pre-treatments, physiological disorders-chilling injury.
7	Improved packaging in vegetable crops.
8-9	Use of chemicals for ripening and enhancing shelf life of vegetables.
10-11	Physiological loss in weight, estimation of transpiration, respiration rate and ethylene release.
12	Storage of important vegetable crops.
13-14	Cold chain management
15-16	Visit to commercial packinghouse, cold storage and control atmosphere storage

RESOURCES

Chadha, K.L. and Pareek, O.P., 1996, Advances in horticulture. Vol. IV. Malhotra Publ. House.

Chattopadhyay, S.K., 2007, Handling, transportation and storage of fruit and vegetables. Gene-Tech books, New Delhi.

Haid, N.F. and Salunkhe, S.K., 1997, Postharvest physiology and handling of fruits and vegetables. Grenada Publ.

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Paliyath G., Murr D.P., Handa, A.K. 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, J. K., 1998, Postharvest physiology of perishable plant products. CBS publishers.

Sudheer, K.P. and Indira, V., 2007, Postharvest technology of horticultural crops. New India Publ. Agency.

Thompson, A.K. (Ed.), 2014, Fruit and vegetables: harvesting, handling and storage (Vol. 1 and 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.

Verma, L.R. and Joshi, V.K., 2000, Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management. Indus Publishing Company, New Delhi, India. ISBN 8173871086.

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

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

Wills, R.B.H. and Golding, J., 2017, Advances in postharvest fruit and vegetable technology, CRC Press, ISBN 9781138894051.

COURSE CONTENT OF Ph. D. DEGREE

Course Title : RECENT TRENDS IN VEGETABLE PRODUCTION

Course Code : VSC 601

Credit hours : (3+0)

THEORY

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

Unit I	:	Solanaceous crops: Tomato, brinjal, chilli, sweet pepper and potato.
Unit II	:	Cole crops: Cabbage, cauliflower, knolkhol and sprouting broccoli.
Unit III	:	Okra, onion, garlic, peas and beans, amaranth and drumstick.
Unit IV	:	Root crops: Carrot, beet root, turnip and radish Cucurbits: Watermelon, muskmelon, cucumber, bottle gourd, bitter gourd, ridge gourd, sponge gourd, pumpkin
Unit V	:	Tuber crops: Sweet potato, Cassava (tapioca), elephant foot yam, other yams and aroids

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
1-2	Present status and prospects of vegetable cultivation	10
3-4	Nutritional and medicinal values of vegetable crops	
	Climate and soil as critical factors in vegetable production; choice of varieties; Hi-tech nursery management; modern concepts in water and	

	weed management; physiological basis of growth, yield and quality as influenced by chemicals and growth regulators; role of organic manures, inorganic fertilizers, micronutrients and biofertilizers; response of genotypes to low and high nutrient management, nutritional deficiencies/disorders and correction methods; different cropping systems; mulching; Protected cultivation of vegetables, containerized culture for year round vegetable production; low cost polyhouse; net-house production; crop modeling, organic gardening; vegetable production for pigments, export and processing of following crops	
Unit I - Solanaceous crops		
5-8	Tomato & brinjal	20
9-12	Chilli and sweet pepper	
13-14	Potato	
Unit II - Cole crops		
15-16	Cabbage	15
17-18	Cauliflower	
19-20	Knolkhol and sprouting broccoli	
Unit III- Okra, onion, garlic, peas and beans, amaranth and drumstick		
21-22	Okra	10
23-24	Onion &garlic	
25-27	Peas	5
	Beans	
28-29	Amaranths	5
	Drumstick	
Unit IV-Root crops and Cucurbits		
30-34	Carrot	10
	Beet root	
	Radish and turnip	
35-40	Watermelon, muskmelon and cucumber	10

	Bottle gourd, bitter gourd, ridge gourd, sponge gourd and pumpkin	
UnitV- Tuber crops		
41-44	Turnip	10
	Sweet potato	
	Cassava (tapioca)	
45-46	Elephant foot	5
47-48	Other yams and aroids	

RESOURCES

Bose, T.K. and Som, N.G., 1986, Vegetable crops of India. Naya prokash.

Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G., 2003, Vegetable crops. Vols. I-III. Naya Udyog.

Chadha, K.L. and Kalloo, G. (Eds.), 1993-94, Advances in horticulture Vols. V-X. Malhotra Publ. House.

Chadha, K.L. (Ed.), 2002, Hand book of horticulture. ICAR.

Chauhan, D.V.S. (Ed.), 1986, Vegetable production in India. Ram prasad and Sons.

Fageria, M.S., Choudhary, B.R. and Dhaka, R.S., 2000, Vegetable crops: production technology. Vol. II. Kalyani.

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Gopalakrishanan, T.R., 2007, Vegetable crops. New India Publ. Agency.

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Hazra, P., 2016, Vegetable science. 2ndedn, Kalyani publishers, Ludhiana.

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

Kallo, G. and Singh, K. (Ed.), 2001, Emerging scenario in vegetable research and development. Research periodicals and Book Publ. House.

Kurup, G.T., Palanisami, M.S., Potty, V.P., Padmaja, G., Kabeerathuma, S. and Pallai, S.V., 1996, Tropical tuber crops, problems, prospects and future strategies. Oxford and IBH.

Rana, M.K., 2008, Olericulture in India. Kalyani Publ.

Rana, M.K., 2008, Scientific cultivation of vegetables. Kalyani Publ.

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

Saini, G.S., 2001, A Text Book of oleri and flori culture. Aman Publishing House.

Salunkhe, D.K. and Kadam, S.S. (Ed.), 1998, Hand book of vegetable science and technology: production, composition, storage and processing. Marcel Dekker.

Shanmugavelu, K.G., 1989, Production technology of vegetable crops. Oxford and IBH.

Singh, D.K., 2007, Modern vegetable varieties and production technology. International book distributing Co.

Singh, N.P., Bhardwaj, A.K., Kumar, A. and Singh, K.M., 2004, Modern technology on Vegetable production. International book distr. Co.

Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2006, Hybrid vegetable development. International book distr. Co.

Singh, S.P. (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, H.C. and Kelly, W.C. (Eds.), 1978, Vegetable crops. Tata McGraw-Hill.

Course Title : ADVANCES IN BREEDING OF VEGETABLE CROPS

Course Code : VSC 602

Credit hours : (3+0)

THEORY

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

Unit I	:	Solanaceous crops - Tomato, brinjal, hot pepper, sweet pepper and potato
Unit II	:	Cucurbits : Watermelon, muskmelon, cucumber, bottle gourd, bitter gourd, ridge gourd, sponge gourd, pumpkin Cole crops : Cabbage, cauliflower and sprouting broccoli
Unit III	:	Legumes and leafy vegetables- Peas and Beans, amaranth, spinach (palak), chenopods and lettuce.
Unit IV	:	Root and bulb crops - Carrot, beetroot, radish, turnip, onion, garlic
Unit V	:	Tuber crops - Sweet potato, tapioca, elephant foot yam, aroids, yams and dioscorea
Unit VI	:	Okra

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
1-7 (General)	Evolution, distribution, cytogenetics, genetics and genetic resources, wild relatives, genetic divergence, hybridization, inheritance of qualitative and quantitative traits, heterosis breeding, plant idotype concept and selection indices, breeding mechanisms, pre breeding, mutation breeding, ploidy breeding, breeding for biotic and abiotic stresses, breeding techniques for improving quality and processing characters, bio-fortification, in–vitro breeding, marker assisted breeding, haploidy, development of transgenic.	20
Unit I- Solanaceous crops		
8-11	Tomato and brinjal,	15
12-15	Chilli and sweet pepper	
16-17	Potato	
Unit II- Cucurbits and Cole crops		
18-20	Watermelon, muskmelon and cucumber	20
21-24	Bottle gourd, bitter gourd, ridge gourd, sponge gourd, pumpkin	
25-28	Cabbage, cauliflower, knoll-khol and broccoli	
Unit III-Legumes and leafy vegetables		
29-30	Peas and beans	10
31-34	Amaranth, spinach (palak), chenopods and lettuce	
Unit IV- Root and bulb crops		
35-38	Carrot, beetroot, radish and turnip	15
39-41	Onion and garlic	

Unit V- Tuber crops		
42-43	Sweet potato and tapioca	15
44-46	Elephant foot yam, aroids, yams and dioscorea	
Unit VI- Okra		
47-48	Okra	05

RESOURCES

Allard, R.W., 1999, Principle of plant breeding. John Willey and Sons, USA.

Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.

Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J., 2005, Plant genetic resources: horticultural crops. Narosa Publ. House.

Fageria, M.S., Arya, P.S. and Choudhary, A.K., 2000, Vegetable crops: Breeding and seed production. Vol. I. Kalyani.

Gardner, E.J., 1975, Principles of genetics. John Wiley and Sons.

Hayes, H.K., Immer, F.R. and Smith, D.C., 1955, Methods of plant breeding. McGraw-Hill.

Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.), 1993, Plant Breeding-principles and prospects. Chapman and Hall.

Hazra, P. and Som, M.G., 2015, Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598 p

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

Kalloo, G., 1988, Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA.

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Kalloo, G., 1998, Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.

Kumar, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops. Agro Botanical Publ.

Paroda, R.S. and Kalloo, G. (Eds.), 1995, Vegetable research with special reference to hybrid technology in Asia-Pacific Region. FAO.

Peter, K.V. and Pradeepkumar, T., 2008, Genetics and breeding of vegetables. Revised, ICAR.

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

Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables Volume II. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.

Peter, K.V. and Hazra, P. (Eds), 2015, Hand book of vegetables Volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.

Rai, N. and Rai, M., 2006, Heterosis breeding in vegetable crops. New India Publ. Agency.

Ram, H.H., 1998, Vegetable breeding: principles and practices. Kalyani Publ.

Simmonds, N.W., 1978, Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publ.

Singh, B.D., 1983, Plant breeding. Kalyani Publ.

Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2004, Hybrid vegetable development. International Book Distributing Co.

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

Course Title : ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS

Course Code : VSC 603

Credit hours : (2+1)

THEORY

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

Unit II : Mechanism and measurements - tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

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

Unit IV : Techniques of vegetable growing under water deficit, water logging, salinity and sodicity

Unit V : Use of chemicals - techniques of vegetable growing under high and low temperature conditions, use of chemicals and antitranspirants in alleviation of different stresses

PRACTICAL

1. Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops.
2. Measurement of tolerance to various stresses in vegetable crops.
3. Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions.
4. Use of chemicals for alleviation of different stresses.
5. Visit to abiotic stress management institute/centres.

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
Unit I		
1-6	Environmental stress-its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.	20
Unit II		
7-12	Mechanism and measurements tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.	20
Unit III		
13-18	Soil plant water relations under different stress conditions in vegetable crops production and their management practices.	20
Unit IV		
19-25	Techniques of vegetable growing under water deficit, water logging, salinity and sodicity	20
Unit V		
26-32	Use of chemicals - techniques of vegetable growing under high and low temperature conditions, use of chemicals and antitranspirants in alleviation of different stresses	20

PRACTICAL

Practical No.	Topic
1-4	Identification of susceptibility and tolerance symptoms to various types of stresses in vegetable crops.
5-8	Measurements of tolerance to various stresses in vegetable crops.
9-12	Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions.
13-14	Use of chemicals for alleviation of different stresses.
15-16	Visit to Abiotic Stress Management Institute/Centers.

RESOURCES

Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J., 2005, Plant genetic resources: horticultural crops. Narosa Publ. House.

Dwivedi, P. and Dwivedi, R.S., 2005, Physiology of abiotic stress in plants. Agrobios.

Janick, J.J., 1986, Horticultural science. 4th Ed. WH Freeman and Co.

Kaloo, G. and Singh, K., 2001, Emerging scenario in vegetable research and development. Research periodicals and book publ. house.

Kaloo, G., 1994, Vegetable breeding. Vols. I-III. Vedams eBooks.

Lerner, H.R. (Eds.), 1999, Plant responses to environmental stresses. Marcel Decker.

Maloo, S.R., 2003, Abiotic stresses and crop productivity.Agrotech Publ. Academy.

Narendra, T. et al., 2012, Improving crops resistance to abiotic stress. Wiley and Sons.US.

Peter, K.V. and Pradeep Kumar, T., 2008, Genetics and breeding of vegetables. (RevisedEd.). ICAR.

Peter, K.V. and Hazra, P. (Eds), 2015,Hand book of vegetables volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.

Peter, K.V. and Hazra, P. (Eds), 2015,Hand book of vegetables volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.

Ram, H.H., 2001, Vegetable breeding. Kalyani.

Rao, N.K. (Eds.), 2016, Abiotic stress physiology of horticultural crops. Springer publication.

Course Title : SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE SEED

Course Code : VSC 604

Credit hours : (2+1)

THEORY

Unit I : Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian minimum seed certification standards, Planning and management of seed certification programmes.

Unit II : Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification schemes.

Unit III : Principles of seed processing, Methods of seed drying and cleaning, seed processing plant- Layout and design, seed treatment, seed quality enhancement, packaging and marketing.

Unit IV : Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open, bulk, controlled, germplasm, cryopreservation), factors affecting seed longevity in storage (Pre and post harvest factors).

Unit V : Seed aging and deterioration, maintenance of seed viability and vigor during storage, storage methods, storage structures, transportation and marketing of seeds.

PRACTICAL

1. General procedures of seed certification
2. Field inspection and standards
3. Isolation and rouging
4. Inspection and sampling at harvesting, threshing and processing
5. Testing physical purity, germination and moisture, grow-out test
6. Visit to regulatory seed testing and plant quarantine laboratories
7. Seed processing plants and commercial seed stores

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
UNIT I		
1-9	Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian minimum seed certification standards, planning and management of seed certification programmes.	20
UNIT II		
10-16	Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification schemes.	20
UNIT III		
17-22	Principles of seed processing, methods of seed drying and cleaning, seed processing plant-layout and design, seed treatment, seed quality enhancement, packaging and marketing.	20
UNIT IV		
23-27	Principles of Seed Storage, orthodox/ recalcitrant seeds, types of storage (open, bulk, controlled, germplasm, cryopreservation), factors affecting seed longevity in storage (Pre and post harvest factors).	20
UNIT V		
28-32	Seed aging and deterioration, maintenance of seed viability and vigor during storage, storage methods, storage structures, transportation and marketing of seeds.	20

PRACTICAL

Practical No.	Topic
1-2	General procedures of seed certification
3	Field and seed inspection

4	Management of isolation distance in seed production
5	Practices in rouging in seed plot
6-8	Seed sampling, purity, moisture testing and quick test of germination
9-10	Seed viability and seed vigor tests of vegetable seeds
11	Seed priming and pelleting, mixing and dividing instruments
12	Seed cleaning, grading, processing and packaging and storage
13	Inspection at harvesting, threshing and processing
14	Seed treatment methods
15	Visit to seed testing and plant quarantine laboratories
16	Visit to seed processing unit and warehouses and commercial seed stores

RESOURCES

Agarwaal, P. K. and Anuradha, V., 2018, Fundamentals of seed science and technology. Brilliant publications, New Delhi.

Basra, A. S., 2000, Hybrid seed production in vegetables. CRC press, Florida, USA.

Bench, A.L.R. and Sanchez, R.A., 2004, Handbook of seed physiology. Food products press, NY/ London.

Chakraborty, S. K., Prakash, S., Sharma, S.P. and Dadlani, M., 2002, Testing of distinctiveness, uniformity and stability for plant variety protection. IARI, New Delhi

Copland, L.O. and McDonald, M.B., 2004, Seed science and technology, Kluwer academic press.

Fageria, M.S., Arya, P.S. and Choudhry, A.K., 2000, Vegetable crops: breeding and seed production Vol 1. Kalyani publishers, New Delhi.

George, R.A.T., 1999, Vegetable seed production (2nd Edition). CAB International.

Hazra, P. and Som, M.G., 2016, Vegetable seed production and hybrid technology(Second revised edition), Kalyani publishers, Ludhiana, 459 p

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Singhal, N.C., 2003, Hybrid seed production. Kalyani publishers, New Delhi.

Course Title : BREEDING FOR SPECIAL TRAITS IN VEGETABLE CROPS

Course Code : VSC 605

Credit hours : (2+0)

THEORY

Important nutrient constituents in vegetables and their role in human diet. Genetics of nutrients. Genetic and genomic resources for improving quality traits in vegetables, breeding strategies for developing varieties with improved nutrition for market and industrial purposes. Molecular and biotechnological approaches in breeding suitable cultivars of different crops for micronutrients and color content

Unit I : Brassica group, carrot and beetroot

Unit II : Tomato, brinjal, peppers and potato

Unit III : Green leafy vegetables, legume crops and okra

Unit IV : Cucurbitaceous vegetable crops and edible alliums

Unit V : Bio-fortification in vegetable crops, genetic engineering for improvement of quality traits in vegetable crops, bio-availability of dietary nutrients from improved vegetable crops and impact on micronutrient malnutrition, achievements and future prospects in breeding for quality traits in vegetables.

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
	Important nutrient constituents in vegetables and their role in human diet. Genetics of nutrients. Genetic and genomic resources for improving quality traits in vegetables, breeding strategies for developing varieties with improved nutrition for market and industrial purposes. Molecular and biotechnological approaches in breeding suitable cultivars of different crops for micronutrients and color content.	
UNIT I		

1-5	Brassica group- Cabbage, cauliflower, sprouting brocoli	20
6-8	Carrot and beetroot	
UNIT II		
9-11	Tomato, brinjal	20
12-14	Sweet and hot peppers	
15-16	Potato	
UNIT III		
17-19	Green leafy vegetables- Spinach, fenugreek, coriander and amaranths	10
20-21	Legume crops-Peas and beans	10
22	Okra	
UNIT IV		
23-26	Cucurbitaceous vegetable crops- Watermelon, muskmelon, cucumber, bottle gourd, bitter gourd, ridge gourd, sponge gourd and pumpkin	15
27-29	Edible alliums- Onion and garlic	10
UNIT V		
30-32	Bio-fortification in vegetable crops, genetic engineering for improvement of quality traits in vegetable crops, bio-availability of dietary nutrients from improved vegetable crops and impact on micronutrient malnutrition, achievements and future prospects in breeding for quality traits in vegetables.	15

RESOURCES

Allard, R.W., 1999, Principles of plant breeding. John Wiley and Sons.

Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.

Dhillon, B.S., Tyagi, R.K., Saxena, S. and Randhawa, G.J., 2005, Plant genetic resources: horticultural crops. Narosa Publ. House.

Fageria, M.S., Arya, P.S. and Choudhary, A.K., 2000, Vegetable crops: Breeding and seed production. Vol. I. Kalyani.

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Hayward, M.D., Bosemark, N.O. and Romagosa, I. (Eds.), 1993, Plant Breeding-principles and prospects. Chapman and Hall.

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Peter, K.V. and Pradeepkumar, T., 2008, Genetics and breeding of vegetables. Revised, ICAR.

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

Peter, K.V. and Hazra, P. (Eds), 2015,Hand book of vegetables Volume II.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.

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Rai, N. and Rai, M., 2006, Heterosis breeding in vegetable crops. New India Publ. Agency.

Ram, H.H., 1998, Vegetable breeding: principles and practices. Kalyani Publ.

Rout, G.R. and Peter, K.V., 2008, Genetic engineering of horticultural crops. Academic press, Elsevier, USA

Simmonds, N.W., 1978, Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publ.

Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2004, Hybrid vegetable development. International Book Distributing Co.

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

Course Title : BIODIVERSITY AND CONSERVATION OF VEGETABLE CROPS

Course Code : VSC 606

Credit hours : (2+1)

THEORY

Unit I : General aspects: issues, goals and current status: Biodiversity and conservation; issues and goals- needs and challenges; present status of gene centers; world's major centers of vegetable crop domestication; current status of germplasm availability/database of vegetable crops in India.

Unit II : Germplasm conservation: collection, maintenance and characterization: Exploration and collection of germplasm; sampling frequencies; size and forms of vegetable germplasm collections; active and base collections. Germplasm conservation- in situ and ex situ strategies, on farm conservation; problem of recalcitrance- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.

Unit III : Regulatory horticulture :Germplasm exchange, quarantine and intellectual property rights germplasm exchange, quarantine and intellectual property rights regulatory horticulture, inventory and exchange of vegetable germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged vegetable varieties in India.

PRACTICALS

1. Documentation of germplasm- maintenance of passport data and other records of accessions
2. Field exploration trips and sampling procedures
3. Exercise on ex situ conservation – cold storage, pollen/seed storage
4. Cryopreservation
5. Visits to national gene bank and other centers of PGR activities
6. Detection of genetic constitution of germplasm
7. Germplasm characterization using a standardized DUS test protocol
8. Special tests with biochemical and molecular markers

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
UNIT I - General aspects: Issues, goals and current status		
1-4	Biodiversity and conservation; issues and goals- needs and challenges; present status of gene centers; world's major centers of vegetable crop domestication.	10
5-6	Current status of germplasm availability/database of vegetable crops in India	10
UNIT II- Germplasm conservation: collection, maintenance and characterization		
7-9	Exploration and collection of germplasm; sampling frequencies; size and forms of vegetable germplasm collections; active and base collections.	10
10-13	Germplasm conservation- in situ and ex situ strategies, on farm conservation	10
14-16	Problem of recalcitrance- cold storage of scions, tissue culture, cryopreservation, pollen and seed storage.	10
UNIT III-Regulatory Horticulture		
17-20	Germplasm exchange, quarantine and intellectual property rights germplasm exchange, quarantine and intellectual property rights regulatory horticulture.	10
21-24	Inventory and exchange of vegetable germplasm, plant quarantine, phyto-sanitary certification, detection of genetic constitution of germplasm and maintenance of core collection.	15
25-27	IPRs, Breeder's rights, Farmer's rights, PPV and FR Act. GIS and documentation of local biodiversity	10
28-32	Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI tagged vegetable varieties in India	15

PRACTICAL

Practical No.	Topic
1-2	Documentation of germplasm, maintenance of passport data and other records of accessions.
3-4	Field exploration trips and sampling procedures in vegetable crops.
5-6	Exercise on ex situ conservation – cold storage, pollen/seed storage.
7	Cryopreservation in vegetable crops.
8-9	Detection of genetic constitution of germplasm of vegetable crops.
10-11	Germplasm characterization using a standardized DUS test protocol.
12-14	Special tests with biochemical and molecular markers.
15-16	Visits to national gene bank and other centers of PGR activities.

RESOURCES

Dhillon, B. S., Tyagi, R. K., Lal, A. and Saxena, S., 2004, Plant genetic resource management. – horticultural crops. Narosa publishing house, New Delhi.

Engles, J. M., Ramanath R, V., Brown, A. H. D. and Jackson, M. T., 2002, Managing plant genetic resources, CABI, Wallingford, UK.

Frankel, O.H. and Hawkes, J.G., 1975, Crop genetic resources for today and tomorrow Cambridge University Press, USA.

Hancock, J., 2012, Plant evolution and the origin of crops species. CAB International.

Jackson, M., Ford-Lloyd, B. and Parry, M., 2014, Plant genetic resources and climate change. CABI, Wallingford, UK

Moore, J.N. and Ballington, J.R. 1991, Genetic resources of temperate Fruit and nut crops. ISHS, Belgium.

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Peter, K.V., 2011, Biodiversity in horticultural crops. Vol.III. Daya publ. house, Delhi.

Rajasekharan, P.E., Rao, V. and Ramanatha, V., 2019, Conservation and utilization of horticultural genetic resources. Springer.

Rana, J.C. and Verma, V.D., 2011, Genetic resources of temperate minor fruits (indigenous andexotic). NBPGR, New Delhi.

Sthapit, et al., 2016, Tropical fruit tree diversity (good practices for in situ and ex situ conservation). Bioversity international. routledge, Taylor and Francis Group.

Virchow, D., 2012, Conservation of genetic resources, Springer Verlag, Berlin

Course Title : BIOTECHNOLOGICAL APPROACHES IN VEGETABLE CROPS

Course Code : VSC 607

Credit hours : (2+1)

THEORY

Unit I : Importance and scope of biotechnology - in vegetable crop improvement. In vitro culture, micro-propagation, anther culture, pollen culture, ovule culture, embryo culture, endosperm culture.

Unit II : Somatic embryogenesis - somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion. Somatic hybrids and cybrids and their application in vegetable improvement programme

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

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

UNIT V : Concepts and methods of next generation sequencing (NGS)- Genome sequencing, transcriptomics, proteomics, metabolomics. Genome editing (ZFN, TALENS and CRISPER) Crops: Solanaceous crops, cole crops, cucurbitaceous crops, root vegetables, garden pea, onion, potato and leafy vegetables

PRACTICALS

1. Micro-propagation, Pollen- Ovule and Embryo culture- Synthetic seed production.
2. In vitro mutation induction, in vitro rooting – hardening at primary and secondary nurseries.
3. DNA isolation from economic vegetable crop varieties – Quantification and amplification (2) DNA and Protein profiling – molecular markers, PCR Handling.
4. Vectors for cloning and particle bombardment.
5. DNA fingerprinting of vegetable crop varieties.
6. Project preparation for establishment of low, medium and high cost tissue culture laboratories.

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
UNIT I-Importance and scope of biotechnology -		
1-2	Importance and scope of biotechnology in vegetable crop improvement.	10
3-5	In vitro culture, micro-propagation, anther culture, pollen culture, ovule culture, embryo culture, endosperm culture.	10
UNIT II-Somatic embryogenesis		
6-8	Somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion.	10
9-11	Somatic hybrids and cybrids and their application in vegetable improvement programme	10
UNIT III- Blotting techniques, DNA finger printing		
12-16	Blotting techniques, DNA finger printing. Molecular markers/DNA based markers and role. RFLP, AFLP, RAPD, SSR, SNPs, DNA probes.	10
17-20	QTL mapping. MAS and its application in vegetable crop improvement. Allele mining by TILLING and Eco-TILLING	10
UNIT IV-Plant genetic engineering		
21-23	Scope and importance, Concepts of cisgenesis, intragenesis and transgenesis. Gene cloning, direct and indirect methods of gene transfer.	10
24-26	Role of RNAi based gene silencing in vegetable crop improvement. Bio-safety issue, regulatory issues for commercial approval.	10
UNIT V-Concepts and methods of next generation sequencing (NGS)		
27-29	Concepts and methods of next generation sequencing (NGS)- Genome sequencing, transcriptomics, proteomics, metabolomics.	10
30-32	Genome editing (ZFN, TALENS and CRISPER) crops: Solanaceous crops, cole crops, cucurbitaceous crops, root vegetables, garden pea, onion, potato and leafy vegetables.	10

PRACTICAL

Practical No.	Topic
1-2	Micro-propagation, Pollen- Ovule and Embryo culture- Synthetic seed production..
3-5	In vitro mutation induction, in vitro rooting – hardening at primary and secondary nurseries.
5-7	DNA isolation from economic vegetable crop varieties – Quantification and amplification.
8-9	DNA and Protein profiling – molecular markers, PCR Handling.
10-12	Vectors for cloning and particle bombardment..
13-15	DNA fingerprinting of vegetable crop varieties.
16	Project preparation for establishment of low, medium and high cost tissue culture laboratories.

RESOURCES

Bajaj, Y.P.S. (Ed.), 1987, Biotechnology in agriculture and forestry. Vol. XIX. Hitech and Micro-propagation. Springer.

Chadha, K.L., Ravindran, P.N. and Sahijram, L. (Eds.), 2000, Biotechnology of Horticulture and Plantation crops. Malhotra Publ. House.

Debnath, M., 2005, Tools and techniques of biotechnology. Pointer publication, New Delhi.

Glover, M.D., 1984, Gene cloning: the mechanics of DNA manipulation. Chapman and Hall.

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Keshavachandran, R., 2007, Recent trends in biotechnology of horticultural crops. New India Publ. Agency.

Keshavachandran, R. and Peter, K.V., 2008, Plant biotechnology; tissue culture and gene transfer. Orient and Longman, USA.

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Parthasarathy, V.A., Bose, T.K., Deka, P.C., Das, P., Mitra, S.K. and Mohanadas, S., 2001, Biotechnology of horticultural crops. Vols. I-III. Naya Prokash.

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Sharma, R., 2000, Plant tissue culture. Campus Books.

Singh, B.D., 2010, Biotechnology- expanding horizons. Kalyani Publishers, New Delhi.

Skoog, Y. and Miller, C.O., 1957, Chemical regulation of growth and formation in plant tissue cultured in vitro. Attidel. II Symp. On biotechnology action of growth substance.

Vasil, T.K., Vasi, M., While, D.N.R. and Bery, H.R., 1979, Somatic hybridization and genetic manipulation in plants, plant regulation and world agriculture. Planum Press

Course Title : ADVANCED LABORATORY TECHNIQUES FOR VEGETABLE CROPS

Course Code : VSC 608

Credit hours : (1+2)

THEORY

Unit I : Safety measures and laboratory maintenance - Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce. Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.

Unit II : Destructive and non-destructive analysis methods- Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in vegetable crops.

Unit III : Chromatographic and microscopic analysis- basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration. Application of nuclear techniques in harvested produce. Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in vegetables.

UNIT IV : Sensory analysis - Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.

PRACTICALS

1. Determination of moisture, relative water content and physiological loss in weight
2. Determination of biochemical components in vegetables
3. Calibration and standardization of instruments
4. Textural properties of harvested produce
5. Determination of starch index (SI)
6. Specific gravity for determination of maturity assessment, and pH of produce
7. Detection of adulterations in fresh as well as processed products
8. Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch
9. Estimation of rate of ethylene evolution using gas chromatograph (GC)
10. Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, etc.)

TEACHING SCHEDULE

THEORY

Lecture No.	Topic	Weightage (%)
UNIT I-Safety measures and laboratory maintenance		
1-3	Safety aspects and upkeep of laboratory, sampling procedures for quantitative analysis, determination of proximate composition of horticultural produce.	10
4-6	Standard solutions, determination of relative water content (RWC), physiological loss in weight (PLW), calibration and standardization of instruments, textural properties of harvested produce, TSS, Specific gravity, pH and acidity.	20
UNIT II-Destructive and non-destructive analysis methods		
7-8	Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in vegetable crops.	15
UNIT III- Chromatographic and microscopic analysis		
9-10	Basic chromatographic techniques, GC, HPLC, GCMS, Electrophoresis techniques, ultra filtration.	15
11	Application of nuclear techniques in harvested produce.	05
12-13	Advanced microscopic techniques, ion leakage as an index of membrane permeability, determination of biochemical components in vegetables.	15
UNIT IV-Sensory analysis		
14-15	Importance of ethylene, quantitative estimation of rate of ethylene evolution, using gas chromatograph (GC).	10
16	Sensory analysis techniques, control of test rooms, products and panel	10

PRACTICAL

Practical No.	Topic
1-5	Determination of moisture, relative water content and physiological loss in weight.
6-8	Determination of biochemical components in vegetables.
9-10	Calibration and standardization of instruments.
11-14	Textural properties of harvested produce.
15-18	Determination of starch index (SI).
19-21	Specific gravity for determination of maturity assessment and pH of produce.
22-24	Detection of adulterations in fresh as well as processed products.
25-27	Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch..
28-30	Estimation of rate of ethylene evolution using gas chromatograph (GC).
30-32	Use of advanced microscopes (fluorescent, scanning electron microscope, phase contrast, etc.).

RESOURCES

AOAC International, 2003, Official methods of analysis of AOAC international. 17th Ed. Gaithersburg, MD, USA, association of analytical communities, USA.

Clifton, M. and Pomeranz, Y., 1988, Food analysis - laboratory experiments. AVI publication, USA.

Linskens, H.F. And Jackson, J.F., 1995, Fruit analysis. Springer.

Leo, M.L., 2004, Handbook of food analysis, 2nd Ed. Vols. I-III, USA.

Pomrenz, Y. and Meloan, C.E., 1996, Food analysis - theory and practice. CBS, USA.

Ranganna, S. 2001. Handbook of analysis and quality control for fruit and vegetable products. 2nd Ed. Tata-McGraw-Hill, New Delhi.

Thompson, A.K., 1995, Postharvest technology of fruits and vegetables. Blackwell sciences. USA.

9. List of Journals & e-Resources

Sl. No.	Name of the Journal	ISSN Number
1)	American Journal of Horticultural Sciences	0003-1062
2)	American Potato Growers	
3)	American Scientist	1545-2786
4)	Annals of Agricultural Research	9703179
5)	Annual Review of Plant Physiology	0066-4294
6)	California Agriculture	1097-0967
7)	Haryana Journal for Horticultural Sciences	0970-2873
8)	HAU Journal of Research	0379-4008
9)	Horticulture Research	2052-7276
10)	Hortscience	2327-9834
11)	IIVR Bulletins	1462-0316
12)	Indian Horticulture	0019-4875
13)	Indian Journal of Agricultural Sciences	0019-5022
14)	Indian Journal of Horticulture	0974-0112
15)	Indian Journal of Plant Physiology	2662-2548
16)	Journal of American Society for Horticultural Sciences	0003-1062
17)	Indian Journal of Arecanut, Spice and Medicinal Crops	0972-2483
18)	Journal of Food Science and Technology	0975-8402
19)	Journal of Plant Physiology	0176-1617
20)	Journal of Postharvest Biology and Technology	0925-5214
21)	Postharvest Biology and Technology	0925-5214
22)	Scientia Horticulturae	0304-4238
23)	Seed Research	2151-6146
24)	Seed Science	23171537
25)	South Indian Horticulture	0038-3473
26)	Vegetable Grower	2330-2321

M. Sc. (Hort.) Vegetable Science
Course Structure- at a Glance

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	2+1
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	Master Seminar	0+1
VSC 599	Research	0+30
	Total Credits	**70**

* Compulsory among major course

SEMESTER WISE LAYOUTFOR
M. Sc. (Hort.) VEGETABLE SCIENCE DEGREE PROGRAMME

I Semester

Course No.	Course title	Credit
A) Major courses		
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	2+1
	Total (A)	**6+3=9**
B) Minor courses		
BIOCHEM 501	Basic Biochemistry	3+1
PP 502	Principles of Plant Physiology-II: Metabolic Processes and Growth Regulation	2+1
Agron 502	Principles and Practices of Soil Fertility and Nutrient Management	2+1
	Total (B)	**8+3=11**
C) Supporting courses		
STAT 511	Statistical Methods for Applied Science	3+1=4
	Total (C)	**3+1=4**
D) Common compulsory courses (CCC)		
PGS 501	Library and Information Services	0+1
PGS 504	Basic Concepts in Laboratory Techniques	0+1
	Total (D)	**0+2=2**
	Grand Total (A+B+C+D)	**17+9=26**

* Compulsory among major courses

II Semester

Course No.	Course title	Credit
A) Major courses		
VSC 501*	Production of Cool Season Vegetable Crops	2+1
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 510	Systematics of Vegetable Crops	1+1
VSC 512	Production of Spice Crops	2+1
	Total (A)	**10+6=16****
**** Minimum 8 credits will be offered from the including compulsory course**		
B) Minor courses		
Soil 502	Soil fertility and fertilizer use	2+1
Agron 504	Principles and Practices of Water Management	2+1
GPB 506	Molecular Breeding and Bioinformatics	2+1
	Total (B)	**6+3=9**
C) Supporting courses		
STAT 511	Experimental Designs	2+1=3
	Total (C)	**2+1=3**
D) Common compulsory courses (CCC)		
PGS 502	Technical Writing and Communication Skill	0+1
PGS 503	Intellectual Property and its Management in Agriculture	0+1
	Total (D)	**0+2=2**
	Grand Total (A+B+C+D)	**18+12=30**

* Compulsory among major courses

III Semester

Course No.	Course title	Credit
A) Major courses		
VSC 508	Seed Production of Vegetable Crops	2+1
VSC 509	Production of Underutilized Vegetable Crops	2+1
VSC 511	Organic Vegetable Production	1+1
VSC 513	Processing of Vegetable	1+1
VSC 514	Postharvest Management of Vegetable Crops	2+1
	Total (A)	**8+5=13****
**** Minimum 3 credits will be offered**		
B) Minor courses		
Agron 503	Principles and Practices of Weed Management	2+1
	Total (B)	**2+1=3**
C) Supporting courses		**Nil**
D) Common compulsory courses (CCC)		
PGS 505	Agricultural Research Ethics and Rural Development Programme	1+0=1
PGS 506	Disaster Management	1+0=1
	Total (D)	**2+0=2**
	Grand Total (A+B+C+D)	**12+6=18**

IV Semester

Course No.	Course title	Credit
A) Major courses		
VSC 591	Seminar	0+1=1
	Total	**0+1=1**
Research		
VSC 699	Research	**0+30=30**
	OR	
	Internship/ in-plant training and report writing (IDEA)	**25+05= 30**
Grand Total		**47+58=105**

* Compulsory for Master's programme

** Major credits offered in particular semester

CREDIT REQUIREMENTSFOR Ph. D. (HORTICULTURE)
VEGETABLE SCIENCE

Course Details	Doctoral Degree
Major Courses	12
Minor Courses	06
Supporting / Optional	05
Common PGS Courses	-
Seminar	02
Research	75
Total	**100**

CREDIT LAYOUT FOR Ph. D. (HORTICULTURE)
VEGETABLE SCIENCE

Semester	Major	Minor	Supporting	Seminar	Total	NCCC
I	6	3	3	-	**12**	2
II	3	3	2	-	**8**	2
III	3	-	-	1	**4**	1
IV	-	-	-	1	**1**	-
Total	**12**	**6**	**5**	**2**	**25**	**5**

Ph. D. (Hort.) in Vegetable Science

Course Structure- at a Glance

Code	Course title	Credit hours
Major Courses		**12 Credits**
VSC 601*	Recent Trends in Vegetable Production	3+0
VSC 602*	Advances in Breeding of Vegetable Crops	3+0
VSC 603	Abiotic Stress Management in Vegetable Crops	2+1
VSC 604	Seed Certification, Processing and Storage of Vegetable Crops	2+1
VSC 605	Breeding for Special Traits in Vegetable Crops	2+0
VSC 606	Biodiversity and Conservation of Vegetable Crops	2+1
VSC 607	Biotechnological Approaches in Vegetable Crops	2+1
VSC 608	Advanced Laboratory Techniques for Vegetable Crops	1+2
Minor Courses		**06**
Supporting Courses		**05**
Common compulsory courses		--
VSC 691	Seminar I	0+1
VSC 692	Seminar II	0+1
VSC 699	**Research**	**0+75**
	Total Credits	**100**

***Compulsory among major courses**

Semester-wise layout for Ph. D. (Hort.)Vegetable science

I Semester

Course No.	Course title	Credit
A) Major courses		
VSC 601*	Recent Trends in Vegetable Production	3+0=3
VSC 602*	Advances in Breeding of Vegetable Crops	3+0=3
	Total (A)	**6+0=6**
B) Minor courses		
GPB 602	Advances in Biometrical Genetics	2+1=3
	Total (B)	**2+1=3**
C) Supporting courses		
STAT 604	Advanced Statistical Methods	2+1=3
	Total (C)	**2+1=3**
D) Common compulsory courses (CCC)		
PGS 501	Library and Information Services	0+1
PGS 504	Basic Concepts in Laboratory Techniques	0+1
	Total (D)	**0+2=2**
	Grand Total (A+B+C+D)	**14**

II Semester

Course No.	Course title	Credit
A) Major courses		
VSC 603	Abiotic Stress Management in Vegetable Crops	2+1=3
VSC 604	Seed Certification, Processing and Storage of Vegetable Crops	2+1=3
VSC 605	Breeding for Special Traits in Vegetable Crops	2+0=2
	Total (A)	**6+2=8****
** Minimum 3 credits will be offered		

B) Minor courses		
FSC 603	Recent Developments in Growth Regulation	3+0=3
	Total (B)	**3+0=3**
C) Supporting courses		
Agron 604	Recent trends in weed management	2+0=2
	Total (C)	**2+0=2**
D) Common compulsory courses (CCC)		
PGS 502	Technical Writing and Communication Skill	0+1
PGS 503	Intellectual Property and its Management in Agriculture	0+1
	Total (D)	**0+2=2**
	Grand Total (A+B+C+D)	**15**

III Semester

Course No.	Course title	Credit
A) Major courses		
VSC 606	Biodiversity and Conservation of Vegetable Crops	2+1=3
VSC 607	Bio-technological Approaches in Vegetable Crops	2+1=3
VSC 608	Advanced Laboratory Techniques for Vegetable Crops	1+2=3
VSC 691	Seminar- I	0+1=1
	Total (A)	**5+5=10****
** Minimum 4 credits will be offered		
B) Minor courses		**Nil**
	Total (B)	
C) Supporting courses		**Nil**
	Total (C)	**0+0=0**

D) Common compulsory courses (CCC)		
PGS 505	Agricultural Research Ethics and Rural Development Programme	1+0=1
	Total (D)	**1+0=1**
	Grand Total (A+B+C+D)	**11**

IV Semester

Course No.	Course title	Credit
A) Major courses		
VSC 692	Seminar II	0+1=1
B) Research		
VSC 699	Research	**0+75=75**
	Grand Total	**25+75=100**

V Semester

Course No.	Course title	Credit
Research		
VSC 699	Research	**0+75=75**
	Grand Total	**25+75=100**

VI Semester

Course No.	Course title	Credit
Research		
VSC 699	Research	**0+75=75**
	Grand Total	**25+75=100**

* Compulsory among major courses

** Major credits offered in particular semester

Restructured and Revised Syllabus

Horticultural Sciences

M.Sc. & Ph. D. (Horticulture)

In

Floriculture and Landscaping

Submitted by

Broad Subject Coordinator
Associate Dean, College of Horticulture, Mulde
DBSKKV,Dapoli

Discipline Coordinator
Associate Dean, College of Agriculture, Pune,
MPKV, Rahuri

CONTENTS

A COMMITTEE HAS BEEN CONSTITUTED FOR REVISION OF THEPG SYLLABUS FOR FLORICULTURE AND LANDSCAPING WIDE NO. DBSKKV/ 100 DICC/PGSYLLABI/732/22 DATED- 11 MARCH 2022 IN 100 TH DICC MEETING.

Discipline	**Degree Programme**		**Broad Subject Coordinator (Chairman of FLORICULTURE AND LANDSCAPING Discipline)**	**Discipline Coordinator (Secretary of FLORICULTURE AND LANDSCAPINGDiscipline)**
Floriculture and Landscaping	**M.Sc.**	**Ph.D.**	Dr. P. C. Haldavanekar Associate Dean, College of Horticulture, Mulde DBSKKV,Dapoli	Dr. S. D. Masalkar, Discipline Co-ordinator and Associate Dean, College of Agriculture, Pune, MPKV, Rahuri
				Dr. G. M. Waghmare Member & Head, Department of Horticulture, VNMKV, Parbhani
				Dr. P V Patil Member & Professor, of Horticulture(CAS), College of Agriculture, Pune, MPKV, Rahuri
				Dr.S G Bhalekar Member & Professor, of Horticulture(CAS), College of Agriculture, Pune, MPKV, Rahuri
				Dr. Nitin Gupta Member & Associate Professor of Florticulture, Dr.PDKV, Akola
				Dr. S K Chavan Member & Asst. Professor of Horticulture, Pune, MPKV, Rahuri
				Dr. G. B.Kadam Member & Scientist,ICAR-DFR,Pune
				Dr.Naveen Kumar,Principal Member & Scientist, ICAR-DFR, Pune
				Dr Nitesh Dalvi Member & Asst. Professor of Horticulture, DBSKKV,Dapoli

1. GENERAL INTRODUCTION

Horticulture crops occupy only 8.5 per cent of areable land; they contribute 25.5 per cent of the Agriculture GDP. Plantation crops especially tea, coffee and rubber crops just occupying 0.95 per cent to of cropped area have stake of 15.1 per cent of the total expert earnings of agricultural produce. Therefore, the country has considered horticultural and plantation sector as the growth engine of Agricultural economy. Over last decades, the area under horticultural crops grew by about 3 per cent per annum with increase in annual production by 5.4 per cent and the share of horticulture output in agriculture being more than 33 percent.

It became independent college, subsequently, in several SAU's. At present, the discipline of PSMA has been further bifurcated up to four departments in may agri- horticultural universities in the country. The BSMA constituted by the ICAR vide OO. No.F.No.13(1)/2007-EQR dated January 14, 2008 under Chairmanship of Dr K.V. Peter, Former Vice-Chancellor, formulated the common PG Syllabus for Horticulture discipline for the first time and recommended for implementation of the same uniformly throughout the country. The document was published by the ICAR during April 2009. The said committee, considered four disciplines in horticulture science, viz., Fruit science, Vegetable Science, **Floriculture and Landscaping** and Plantation, Spices, Medicinal and Aromatic Crops instead of one composite discipline, viz., Horticulture. The ICAR in its O.O.F.No.7/6/2017 EQR dt: 04.04.2018has constituted 19 BSMA Committees based on the National Core Group recommendations to look into various issues related to PG Programmes.

2. IMPLEMENTATION OF NEW CURRICULUM

The universities offering PG programmes in FLORICULTURE AND LANDSCAPING need to be supported for establishing specialized laboratories equipped with state of the art equipment's for conducting practical classes. One-time catch-up grant should be awarded to each SAU, offering PG programmes in FLORICULTURE AND LANDSCAPING for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. To execute the new PG programmes in FLORICULTURE AND LANDSCAPING in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

Expected Outcome

- Revamping of post graduate programme in whole of Floriculture and Landscaping throughout the country.
- Imparting quality education.
- Development of technical manpower to cater the need of governments, corporate sector and research organization in India and abroad. Exposure to the faculty in the latest technical knowhow.

The main objectives of the programme:

1. To promote the linkages between academia and industry.
2. To establish newer University – Cooperative R&D together with industry for knowledge creation, research and commercialization.
3. Collaboration between Universities and industries through pilot projects.
4. To develop methods for knowledge transfer, innovation and networking potential.
5. To enhance skill, career development and employability.

Following criteria for IDEA will be taken into consideration:

- At any point of time there will not be more than 50% of students who can opt under IDEA.

- Major Advisor will be from Academia and Co-advisor (or Advisory Committee member)from industry.
- Total credits (30) will be divided into 25 for internship/ in-plant training and5 for writing the report followed by viva-voce similar to dissertation.
- Work place will be industry; however, academic/ research support would be provided by the University or both. MoU may be developed accordingly.
- The IPR, if any, would be as per the University policy.

3. CREDIT REQUIREMENTS

Courses	**Masters' Programme**	**Doctoral Programme**
(i) Course work		
Major Courses	20	12
Minor Courses	08	06
Supporting Course(s)	06	05
Common compulsory courses	05	-
Seminar	01	02
(ii) Comprehensive Exam	-	Non-credit course
(iii) Thesis/ Research	30	75
Total	**70**	**100**

4. SUPPORTING COURSES

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

5. COMPULSORY NON-CREDIT DEFICIENCY COURSES

Course code	Course Title	Credit Hours
PGS-501	Library and Information Services	0+1
PGS-502	Technical Writing and Communications Skills	0+1
PGS-503	Intellectual Property and its Management inAgriculture	1+0
PGS-504	Basic Concepts in Laboratory Techniques	0+1
PGS-505	Agricultural Research, Research Ethics and rural development programme.	1+0

6. Minor Courses from other Discipline for M.Sc. Courses & Credit Requirements

Department	Course No	Course Title	Credits
Genetics And Plant Breeding	GPB 502	Principles of Plant Breeding	(2+1)
	GPB 514	Breeding Fruit Crops	(2+1)
Plant Physiology	PP 501	Principles of Plant Physiology-I: Plant Water Relations and Mineral Nutrition	(2+1)
	PP 502	Principles of Plant Physiology-II: Metabolic Processes and Growth	(2+1)

		Regulation	
	PP 503	Plant Developmental Biology: Physiological and Molecular Basis	(2+1)
	PP 510	Seed Physiology	(2+1)
Agronomy	AGRON 501	Modern Concepts in Crop Production	(3+0)
	AGRON 502	Principles and practices of soil fertility	(2+1)
	AGRON 503	Principles and Practices of Weed Management	(2+1)
	AGRON 504	Principles and Practices of Water Management	(2+1)
	AGRON 505	Agrometeorology and weather forecasting	(2+1)
Soil Science	SOIL 501	Soil physics	(2+1)
	SOIL 502	Soil fertility and fertilizer use	(2+1)
	SOIL 503	Soil chemistry	(2+1)
	SOIL 504	Soil mineralogy, genesis and classification	(2+1)
Fruit Science	FSC-501	Tropical fruit production	(2+1)
	FSC 502	Subtropical 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 507	Growth and Development of Fruit Crops	(2+1)
Vegetable Science	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	(2+1)
Plantation Spices	PSMA 501	Production of Plantation Crops	2+1

Medicinal and Aronatic Crops	PSMA 502	Production of Spice Crops	2+1
	PSMA 503	Production of Medicinal and Aromatic Crops	2+1
	PSMA 504	Breeding of Plantation and Spice Crops	2+1
	PSMA 505	Breeding of Medicinal and Aromatic Crops	1+1
Plant Pathology	PL PATH 501	Mycology	(2+1)
	PL PATH 502	Plant Virology	(2+1)
	PL PATH 503	Plant Pathogenic Prokaryotes	(2+1)
	PL PATH 504	Plant Nematology	(2+1)
	PL PATH 505	Principles of Plant Pathology	(2+1)
	PL PATH 506	Techniques in Detection and Diagnosis of plant Diseases	(0+2)
	PL PATH 515	Diseases of Field and Medicinal Crops	(2+1)

Note: Other than above courses student may select required courses with the permission of SAC

7. Minor Courses from other Disciplines for Ph.D.- Course Structure &Credit Requirements

Department	Course No	Course Title	Credit
Fruit Science	FSC 601	Innovative Approaches in Fruit Breeding	3+0
	FSC 602	Modern Trends in Fruit Production	3+0
Vegetable science	VSC 601	Recent Trends in Vegetable Production	3+0
	VSC 602	Advances in Breeding of Vegetable Crops	3+0
Floriculture	FLS 601	Crop Regulation in Ornamental Crops	1+1

and landscaping			
	FLS 602	Postharvest Biology of Floricultural Crops	2+1
	FLS 605	Advances in Landscaping	1+1
Genetics and Plant Breeding	GPB 601	Advances in Plant Breeding Systems	3+0
	GPB 605	Genomics in Plant Breeding	3+0
	GPB 609	IPR and Regulatory Mechanism (e-course)	1+0
Plant Physiology	PP 602	Signal Perceptions and Transduction and Regulation of Physiological Processes	2+0
	PP 607	Physiological and Molecular Aspects of Source-sink Capacity for Enhancing Yield	3+0
Biochemistry	BIOCHEM 603	Biochemistry Of Biotic And Abiotic Stresses	3+0
Soil Science	Soil 606	Soil resource management	3+0
Agronomy	Agron 601	Current trends in Agronomy	3+0
	Agron 608	Research and Publication ethics	2+0
Soil Science	Soil 603	Physical chemistry of soil	2+0
	Soil 604	Soil genesis and micromorphology	2+0
Plant pathology	PL PATH 604	Molecular Basis of Host-pathogen Interaction	2+1
Entomology	ENT 605	Bio-inputs for Pest Management	2+1

Note: Other than above courses student may select required courses with the permission of SAC

8. ORGANIZATION OF COURSE CONTENTS

8.1. Nomenclature of Degree Programme

(a) M.Sc. (Hort.) FLORICULTURE AND LANDSCAPING

(b) Ph.D. (Hort.) FLORICULTURE AND LANDSCAPING

8.2. Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars forDoctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

8.3. Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This doesnot obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is providedat the end which may be useful as study material for 600/700 series courses as well as research topics.
- Lecture schedule and practical schedule has also be given at the end of each course to facilitate the teacher to complete the course in an effective manner.

9. SEMESTER WISE LAYOUT FOR M. SC. (Hort.)
FLORICULTURE AND LANDSCAPING

I SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FLS 501*	Systematics of Ornamental Plants	2+1
FLS 502*	Breeding of Ornamental Plants	2+1

FLS 510	Protected Cultivation of Flower Crops	2+1
FLS 508	Turf Grass Management	2+1
	****Total 9 credits will be offered**	
	Total (A)	**9**
	B) Minor courses	
AGM 509	Weather Forecasting/ other courses from Meteorology /GPB / MBM/ Agril. Economics as per SAC recommendations	2+1=3
BIOCHEM 501	Basic Biochemistry/ other courses from Biochemistry/SSAC/ Meteorology /GPB / MBM/ Agril. Economics as per SAC recommendations	2+1=3
	Total (B)	**6**
	C) Supporting Courses	
STAT 511	Experimental Designs Or other courses from Agril. Statistics/ Agril. Economics as per SAC recommendations	2+1
	Total (C)	**3**
	D) Non Credit Courses	
PGS 501	Library and Information Services	0+1
PGS 504	Basic Concept in Laboratory Techniques	0+1
	Total (D)	**2**
	Total (A+B+C+D)	**20**

***Compulsory course**

Note: One course should be selected from non compulsory courses.

II SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FLS 503*	Commercial Production of Cut Flowers	2+1

FLS 504*	Commercial Production of Loose Flowers	2+1
FLS 507	Nursery Management in Ornamental Plants	2+1
FLS 509	Value Addition in Floriculture	2+1
FLS 511	CAD for Landscaping	1+2
	****Total 9 credits will be offered**	
	Total (A)	**9**
	B) Minor courses	
GPB 516	Breeding for Stress Resistance and climate change/ other courses from GPB/SSAC/ Plant physiology/ Biochemistry/SSAC/ Meteorology / MBM/ Agril. Economics as per SAC recommendations	2+1=3
	Total (B)	**3**
	C) Supporting Courses	
STAT 502	Statistical Methods for Applied Sciences/ Or other courses from Agril. Statistics/ Agril. Economics as per SAC recommendations	3+1=4
	Total (C)	**4**
	D) Non Credit Courses	
PGS 502	Technical Writing and Communication Skill	0+1
PGS 503	Intellectual Property and its Management in Agriculture	1+0
	Total (D)	**2**
	Total(A+B+C+D)	**18**

***Compulsory course**

III SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FLS 505*	Ornamental Gardening and Landscaping	2+1
FLS 506	Indoor Plants and Interiorscaping	1+1

FLS 512	Seed Production in Flower Crops	1+1
	****Total 5 credits will be offered**	
	Total (A)	**5**
FLS599	Research	0+12
	B) Minor courses	**NIL**
	C) Supporting Courses	**NIL**
	D) Non Credit Courses	
PGS 505	Agricultural Research, Research Ethics and RuralDevelopment Programme	1+0
	Total (D)	**1**
	Total	**18**

***Compulsory course**

IV SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FLS 591	Seminar	0+1
	Total (A)	**1**
Research		
FLS 599	Research	0+18*
	Total Research Credit	**18**
	Total	**19**

Or Research 0+13 and IDEA[#] 0+5

 # Internship for Development of entrepreneurship in Agriculture (IDEA)

M.Sc : No Comprehensive qualifying Exam

CREDIT LAYOUT FOR M. Sc. (Hort.)
Floriculture and Landscaping

Semester	Major 20	Minor 8	Supporting 6	Seminar 1	CCC 5	Total
I	9	6	3	-	2	20
II	9	3	4	-	2	18
III	5	-	-	-	1	6
IV	-	-	-	1	-	1
Total	23	9	7	1	5	45

Remedial Non Gradial compulsory Courses

Deficiency courses:

Make up courses for B. Sc. (Agriculture) Students seeking admission for M.Sc. (Hort.) FLS

Sr. No.	Course No.	Title	Credits
1	H/FL 364	Breeding and seed production of ornamental crops	2+1=3
2	H/FL 353	Principles of Landscape Architecture	0+1=1

Deficiency courses:

Make up courses for B. Sc. (Forestry) Students seeking admission for M.Sc. (Hort.) FLS

Sr. No.	Course No.	Title	Credits
1	H/FL 231	Commercial Floriculture	2+1=3
2	H/FL 242	Ornamental Horticulture	2+1=3
3	H/FL 364	Breeding and seed production of ornamental crops	2+1=3
4	H/FL 353	Principles of Landscape Architecture	0+1=1

10. M.Sc. FLORICULTURE AND LANDSCAPING COURSE STRUCTURE AND COURSE CONTENT

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	1+1
FLS 502*	Breeding of Ornamental crops	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 for 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	**83**

***Compulsory among major courses**

Course Title : Systematics of Ornamental Plants
Course Code : FLS 501
Credit Hours : (1+1)

Theory:

Lecture No /	Topics	Weightage (%)
Block I	**Nomenclature**	
1	History, origin, hotspots of Ornamental Plants	**5**
	Classification of Ornamental plants Nomenclature	**5**
2	International systems, Code and Treaties for ornamental plants	**5**
	International and National Organisations, Biodiversity Act of Ornamental Plants	**5**
3	Identification features and descriptors for Ornamental Plants	**5**
	Red Book, Registration (NBPGR, PPVFRA, NBA) for Ornamental Plants	**5**
Block – I	**Families**	
4	Description and important genera of Rosaceae family	**5**
	Description and important genera of Asteraceae,	**5**
5	Description and important genera of Caryophyllaceae	**5**
	Description and important genera of Orchidaceae,	**5**
6	Description and important genera of Aracaceae	**5**
7	Description and important genera of Liliacae.	**5**
Block – II	**Families**	
8	Description and important genera of Acanthaceae,	
9	Description and important genera of Palmaceae,	**5**
10	Description and important genera of Asparagaceae,	**5**
11	Description and important genera of Malvaceae,	**5**

12	Description and important genera of Musaceae,	**5**
13	Description and important genera of Oleaceae,	**5**
14	Description and important genera of Iridaceae	**5**
15	Description and important genera of Amaryllidaceae.	**5**
Block – III	Molecular techniques	
16	Molecular techniques in modern systematics .	**5**

Practical:

1-2	Different nomenclature systems of plants
3-8	Floral biology and taxonomic description of rose, chrysanthemum, orchids, carnation, gerbera, anthurium, marigold, tuberose, Jasmine, China aster, lilium, gypsophila
9-12	Cyropreservation and tissue culture repository
13-16	Molecular techniques.

I. Suggested Reading

Bhattacharya B and Johri BM. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Pub.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 BotanicalNomenclature*. CSIRO Publ., Australia., 176 p.

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

Course Title : Breeding of Ornamental Crops
Course Code: FLS 502
Credit Hours : (2+1)

Theory:

Lecture No /	Topics	Weightage (%)
Block I	Principles of Plant Breeding	
1	Principles of plant breeding	5
2	History/Origin, evolution, distribution, introduction, domestication and conservation of ornamental crops.	5
3	Objectives and Techniques in Ornamental Plant Breeding	5
4-5	Intellectual Property and Plant Breeders Rights, Introduction and initiatives in IPR and PBR of ornamental crops.	5
6-7	Breeding objectives, reproductive barriers (Male sterility, incompatibility) 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 in major ornamental crops viz.,	10
8-9	Rose	5
10-12	Jasmine, Hibiscus, Bougainvillea	5
13-16	Chrysanthemum, Gerbera, China aster, Gaillardia, Dehlia, Zinnia, Carnation ,Marigold,	10
17-18	Tuberose, Gladiolus, Lilium. Orchid	5
19-20	Anthurium, Heliconia	5
21-25	Putunia, Dianthus, Cosmos, Stock, Snapdragon, Pansy, Crossandra, Calendula ,Balsam, Dianthus.	5

26	Annual chrysanthemum (Bijali), heliconia Kalanchoe	5
Block II	Breeding methods	
27-28	Developing Promising cultivars/F1 Hybrids through different breeding methods suitable for sexually, asexually propagated flower crops, self and cross pollinated crops	10
29	Pedigree selection, backcross, clonal selection, polyploidy and mutation breeding	5
30	Role of heterosis and its exploitation	5
31-32	Role of biotechnology in improvement of flower crops including somaclonal variation, in-vitro mutagenesis, in-vitro selection, genetic engineering, molecular markers, etc.	10

Practical:

P. No.	Practical
1-2	Floral biology of important ornamental crops
3-4	Cytology and cytogenetics
5-6	Selfing and crossing for important ornamental crops
7-8	Evaluation of hybrid progenies
9-10	Induction of mutants through physical and chemical mutagens
11-12	*In-vitro* selection, genetic engineering
13-14	Induction of polyploidy
15-16	DUS testing

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.

Course Title : Commercial Production of Cut Flowers
Course Code: FLS 503
Credit Hours : (2+1)

Theory:

Lecture No	Topics	Weightage (%)
Block I	Production management	
1	National and International scenario, importance and scope of cut flower trade, constraints for cut flower production in India.	10
2-3	Growing environment: Soil 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.	10
4-6	Crop management: Commercial Flower production – Commercial varieties, water and nutrient management, fertigation, weed management, crop specific practices, rattoning, training and pruning, pinching, deshooting, bending, desuckering, disbudding. Use of growth regulators, physiological disorders and remedies, IPM and IDM.	10
Block I	Production management	
	Flower regulation: Flower forcing and year round/ offseason flower production through physiological interventions, chemical regulation, environmental manipulation. Growing Environment, Crop Management and flower regulation for Various Crops viz.,	
7-8	Cut Rose and Cut Chrysanthemum	10

9-10	Anthurium and Orchid	10
11-12	Carnation and Gerbera	10
13-14	Gladiolus and Tuberose	10
15-18	China aster, Liliums, Birds of Paradise, Heliconia Alstromeria, Ornamental Ginger, Bromeliads, Dahlia, Gyposophilla and costus	5
19-21	Solidago, Limonium, Statice , Stock, Cut foliages and Fillers	5
Block – II	Post-harvest management and marketing	
22-23	Cut flower standards and grades, harvest indices and harvesting techniques.	10
24-26	Post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, storage and transportation of cut flowers.	10
27-29	Marketing: Marketing, export potential, institutional support for cut flower production	10
30-32	Agri Export Zones, 100% Export Oriented units, Crop Insurance for cut flowers	

Practical:

P. No.	Practical
1	Identification of varieties
2-3	Propagation
4-5	Microclimate management
6	Training and pruning techniques
7	Pinching, deshooting, disbudding, desuckering
8-9	Practices in manuring, drip and fertigation, foliar nutrition, growth regulator application

10-11	Harvesting techniques, post-harvest handling, cold chain
12-13	Economics, Project preparation for regionally important cut flowers, crop specific guidelines for project financing (NHB guidelines)
14-15	Visit to commercial cut flower units
16	Case studies

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.

Course Title : Commercial Production of Loose Flowers
Course Code: FLS 504
Credit Hours : (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Production management	
1	Scope, scenario and importance of loose flowers.	10
2	Constraints and opportunities in loose flower production	
3-4	Growing environment: Nursery management, pro-tray nursery under shade nets, soil and climate requirement, Field preparation, systems of planting.	
5-8	Crop management: Soil 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.	5
Block I	Production management	
	Crop regulation: Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation. Growing Environment, Crop Management and flower regulation for Various Crops viz.,	
9-11	Jasmine and Scented Rose	10
12-13	Chrysanthemum , Marigold	10
14-16	Tuberose, china aster, Crossandra, Gaillardia , Hibiscus,	15
17-18	Nerium, Barleria, Celosia Gompherena	10

19-20	Nontraditional flowers (Nycanthes, Tabernaemontana,)	10
21-24	Non traditional flowers(Madar water lily, Lotus, spider lilies , tecoma, champaca, pandanus, gardenia and balsum)	10
Block – II	Post harvest management and marketing	
25-27	Harvesting indices, harvesting techniques of Loose flowers	10
28-30	Post-harvest handling and grading, pre-cooling, packaging and storage of Loose flowers.	5
31-32	Important local markets, Export potential, transportation and marketing, APMC and online trading, institutional support, Crop Insurance for Loose flowers.	5

Practical:

P. No.	Practical
1	Identification of species and varieties
2	Propagation and nursery management
3	Training and pruning techniques
4-5	Fertigation, foliar nutrition, growth regulator application
6-7	Crop protection
8	Pinching, disbudding, staking, harvesting techniques
9-10	Post-harvest handling, storage and cold chain
11-12	Project preparation for regionally important commercial loose flowers crop specific guidelines for project financing (NHB guidelines)
13-14	Cost Economics
15-16	Exposure Visits to fields

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.

Course Title : Ornamental Gardening And Landscaping
Course Code : FLS 505
Credit Hours : (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Gardens and components	
1-2	Styles and types of gardens : Historical background of gardening, Importance and scope of ornamental gardening	10
3-5	Formal and informal style gardens- English, Mughal, Japanese, Persian, Spanish, Italian, French, Hindu and Buddhist gardens.	10
6-8	Garden Components (Living and Non Living) – Living Components- Arboratum, 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	10
Block I	Gardens and components	
9-11	Non Living Components- Adornments,; 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.	10
12-13	Lawn Making-Genera and species, establishment and maintenance.	10
14-16	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.	10

Block – II	Landscape planning	
17-20	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.	10
21-24	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.	10
Block II	Landscape planning	
25-28	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 ,Topiary, Road divider planting , xeriscaping, airports, railway station and tracks, river banks and dam sites and IT/ SEZ parks.	10
29-32	Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening.	10

Practical:

P. No.	Practical
1	Graphic language and symbols in landscaping, study of drawing instruments, viz., 'T' square, setsquare, drawing board, etc.
2	Identification of various types of ornamental plants for different gardens and occasions
3	Preparation of land, planning, layout and planting, deviations from landscape principles
4	Case study

5	Site analysis, interpretation of map of different sites, use of GIS for selection
6-7	Enlargement from blue print. Landscape design layout and drafting on paper as per the scale
8-10	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.
11-12	Burlapping, lawn making, planting of edges, hedges, topiary, herbaceous and shrubbery borders
13-14	Project preparation on landscaping for different situations, creation of formal and informal gardens, Software for landscape design
15-16	Visit to parks and botanical gardens

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.

Course Title : Indoor Plants and Interior scaping
Course Code : FLS 506
Credit Hours : (1+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Scope, principles and operations	
1	Importance and scope of indoor plants	5
2	Interior scaping, Indoor plants and Indoor air quality.	5
3	Classification and principles: Factors affecting growth, development and flowering of Indoor plants.	10
4	Classification of indoor plants based on light, temperature, humidity and pollution tolerance,.	10
5	Description and cultivation of various indoor plants.	10
6	Principles of Interiorscaping, Role in pollution mitigation.	10
7 & 8	Cultural operations: Containers and substrates, preparation of growing media, propagation, training, grooming, nutrition, management of disease, pests and weeds.	10
9 & 10	Maintenance of plants including repotting, foliar nutrition, light exposure and plant rotation. Media standards, Nursery and Export standards for potted plants, Nursery standards.	10
Block – II	Presentations and marketing	
11	Special gardens including miniature gardens and plant stand.	5

12 & 13	Presentations like dish, terrarium, bottle gardens, hanging baskets, window boxes and Bonsai.	10
14 & 15	Vertical gardens- History, planting material, structures, containers, substrate, water and nutrient management, supplemental lighting.	10
16	Marketing channels, Business models including plant rentals	5

Practical:

P. No.	Practical
1-2	Identification of important house plants
3	Media and containers
4	Propagation
5-6	Cultural operations, maintenance and economics of indoor plants
7-8	Familiarization with different indoor gardens
9-10	Models for Interiorscaping
11-12	Making of terrariums, bottle garden, dish garden and their economics
13-14	Making of vertical gardens and economics
15-16	Exposure visits

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.

Course Title : Nursery Management for Ornamental Plants
Course Code: FLS 507
Credit Hours : (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Nursery Industry and Propagation	
1-2	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.	10
3	Sexual propagation, Merits and Demerits	5
4-5	Factors influencing seed germination of flower crops, dormancy, seed quality, packing, storage. Certification and testing.	10
6	Hormonal regulation of germination and seedling growth.	5
7-9	Asexual propagation, Methods of asexual propagation, rooting of soft and hard wood cutting under mist.	5
10-11	Plant growth regulators. Physiological, anatomical and biochemical aspects of root induction in cuttings	5
12-16	. Layering – principles and methods, budding and grafting – selection of elite mother plants. Stock, scion and inter stock, relationship – Incompatibility.	10
17-19	Micropropagation: Micro-propagation – principles and concepts, commercial exploitation in flower crops.	10
20-22	Techniques – in-vitro clonal propagation, direct organogenesis, embryogenesis, micrografting,	10

	meristem culture.	
23-24	Hardening, packing and transport of micro-propagules.	10
Block – II	Nursery Management	
25-27	Growing structures: Growing structures like mist chambers, tunnels, lath house, net house, growing media types, soil less culture and containers. Automation in nursery management.	10
28-31	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.	15
32	Standards: Nursery standards, Hi-tech nurseries, garden centers.	5

Practical:

P. No.	Practical
1-2	Anatomical studies in rooting of cutting and graft union
3-4	Identification and production of plug plants, seedlings and saplings
5-6	Preparation of growing media and use of PGRs
7	Practice of propagation through specialized structures cuttings, layering
8	Nutrient and water management
9-10	budding and grafting

11-13	Case studies
14	Micropropagation of ornamental crops and hardening
15	Visit to tissue culture labs and nurseries
16	Economics

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.

Course Title : Turf grass Management
Course Code : FLS 508
Credit Hours : (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Turf industry and turf grasses	
1	Prospects and basic requirement: History, present status and prospects of turf industry	10
2,3	Basic requirements, site selection and evaluation, concepts of quality of soil pertaining to turf grass establishment, Criteria for evaluation of turf quality.	10
4,5,6	Types, species, varieties, important breeders, grasses for different locations and conditions and their compatible groupings as per climatic conditions.	10
7	Turfing for roof gardens.	10
8,9,10	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.	10
11,12	Turf management – Irrigation, drainage, nutrition, special practices like aerating, rolling, coring, dethatching, verticutting, soil top dressing.	10
13	Use of plant growth regulators and micronutrients.	10
14,15	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.	10
Block II	Turf for different grounds	
16,17	Making of different sports arenas: Establishment and maintenance of turfs for playgrounds, viz., golf,	10

	football, hockey, cricket, tennis, rugby, residential and public parks, turfing of Govt. and Corporate office gardens, event specific preparation, turf colourants.	
19	Automation: Exposure to different tools, gadgets, machinery used in turf industry.	10

Practical:

P. No.	Practical
1	Identification of turf grasses and turf machinery
2-3	Soil preparation, turf establishment methods, provision of drainage
4	Layout of macro and micro irrigation systems
5-6	Water and nutrient management
7-8	Special practices – mowing, raking, rolling, soil top dressing, weed management
9-10	Biotic and abiotic stress management
11-12	Project preparation for turf establishment
13-14	Visit to parks, model cricket grounds and golf courses, airports, corporates, Govt. organizations
15	Rejuvenation of lawns
16	Turf economics

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.

Course Title : Value Addition in Floriculture
Course Code : FLS 509
Credit Hours : (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Value added products	
1	Scope and scenario: Scope and prospects of value addition, National and global scenario, production and exports.	10
2	Types of value added products, techniques of value addition including tinting.	10
3	Value addition in loose flowers and product development.	10
4	Gulkhand, floral tea, rose oil, rose water, Pankhuri, floral dyes, rose sherbet, floral ice creams, sweets, etc.	5
5,6	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.	10
7,8	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,	10
9,10	Techniques in dry flower making – Drying, glycerising, bleaching, dyeing, embedding, pressing.	10

11,12	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 moulds.	10
Block II	Extraction of value added products	
13,14	Essential oils: Essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packing and storage, Aromatherapy.	10
15,16,17	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.	10
18	Dying: Synthetic and Natural dyes, dying techniques, colour retention.	5

Practical:

P. No.	Practical
1-4	Practices in preparation of different type of flower arrangements including bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers
5-6	Techniques in flower arrangement and floral decoration
7-8	Identification of plants for dry flower making
9-10	Practices in dry flower making; Preparation of dry flower baskets, bouquets, pot- pourri, wall hangings, button holes, greeting cards, wreaths, etc.
11	Essential oil extraction units
12-13	Extraction of pigments
14-15	Visit to dry flower units
16	Economics of value added products

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.

Course Title : Protected Cultivation of Flower Crops
Course Code : FLS 510
Credit Hours : (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Principles and types	
1	Prospects and types of protected structures: Prospects of protected floriculture in India	10
2	Types of protected structures – Glasshouse/ polyhouse, shade net houses, mist chambers, lath houses, orchidarium, fernery, rain shelters, etc.	10
3	Principles of designing : Principles of designing and erection of protected structures; Low cost/ Medium cost/ High cost structures.	10
4	Location specific designs: Structural components; suitable flower and foliage plants for protected cultivation.	10
Block II	Growing environment	
1	Control of environment: Microclimate management and manipulation of temperature, light, humidity, air and CO2, Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation, water harvesting.	20
2	Containers and substrates, media, soil decontamination, layout of drip and fertigation system, water and nutrient management, IPM and IDM.	10
3	Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.	10

4	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	10
5	Crops: Rose, Chrysanthemum, Carnation, Gerbera, Orchids, Anthuriums, Lilium, Limonium, Lisianthus, heliconia, Cala lily, Alstromeria, Gypsophila and statis	10

Practical:

P. No.	Practical
1	Study of various protected structures
2-3	Design, layout and erection of different types of structures
4-5	Practices in preparatory operations, growing media, soil decontamination techniques
6-7	Microclimate management
8-9	Practices in drip and fertigation techniques, special horticultural practices
10	Determination of harvest indices and harvesting methods
11	Postharvest handling, packing methods
12-13	Economics of cultivation, Project preparation
14	Project Financing guidelines
15-16	Visit to commercial greenhouses

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.

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.

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

Course Title : CAD for Landscaping
Course Code : FLS 511
Credit Hours : (1+2)

Theory:

Lecture No.	Topics	Weightage (%)
Block I	CAD	
1	Automation and standards: CAD –Defination, Use, History, Importance, applications and Merits and Demerits.	10
2	Principles of integrating the architecture and landscaping	5
3,4	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	20
5,6 ,7,8	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.	20
Block II	ARCHICAD	
9,10,11 and 12	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)	20
13	Creation of garden components through ARCHICAD.	5

14,15,16,17, 18	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.	20

Practical:

P. No.	Practical
1-4	Practices in point picking methods, Using tool bars and icons, Using modifying tools and modifying comments
5-6	Isometric drawings, Using productivity tools
7-10	Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden
11-14	Using tools and info-box for 3D drawing, Creation of garden components with ARCHICAD
15-18	Organization, dimensioning, detailing and visualization tools with ARCHICAD
19-20	Using Photoshop package for 3D picture insertion
21-28	Drawing designs with ARCHICAD for home garden, interior garden designing, IT parks, Corporates, Theme parks and Ecotourism spots
29-32	Exposure visits

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.

Course Title : Seed Production in Flower Crops
Course Code : FLS: 512
Credit Hours : (1+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Seed Industry	
1	Scenario of Seed Industry: Scope, scenario and importance of seed production in flower crops.	5
2	Constraints in flower seed production. Marketing and economics of flower seeds.	5
Block II	Hybrid Seed Production	
3	Seed production-Methods: Methods of seed production.	10
4	Agrotechniques for production of nucleus, breeder and certified seeds.	10
5	Harvesting, seed processing, seed priming, seed chain, packaging and storage.	10
6	Population improvement: Mass selection, progeny selection.	10
7	Use of incompatibility and male sterility, maintenance of variety and seed production in flower crops.	10
Block II	Hybrid Seed Production	
7-8	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.	10
9-11	Population improvement: Population improvement: Mass selection, progeny selection. Use of	10

	incompatibility and male sterility, maintenance of variety and seed production in flower crops.	
12-14	F1 hybrid : 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.	10
Block III	Regulations	
15-16	Seed certification, Seed 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 phytosanitary issues, custom clearance and quarantine.	10
	Crops Marigold, Aster, balsam and gaillardia, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum, poppy, corn flower, rice flower	

Practical:

P. No.	Practical
1-2	Seed production of open pollinated varieties
3-4	Seed production of cross pollinated varieties
5-6	Steps involved in hybrid seed production
7-12	Hybrid seed production in different flower crops like marigold, petunia,
	antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower,
	annual chrysanthemum, Aster, balsam and gaillardia
13-15	Visit to seed industry
16	Visit to quarantine facility

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.

Course Title with Credit Load
Ph.D. (Hort.) in Floriculture and Lanscaping

Course Code	Course Title	Credit Hours
FLS 601*	Crop Regulation in Ornamental Crops	2+1
FLS 602*	Postharvest Biology of Floricultural Crops	2+1
FLS 603	Specialty Flowers, Fillers and Cut Greens	1+1
FLS 604	Biotechnological Approaches in Floricultural Crops	2+1
FLS 605*	Vertical Gardening	1+2
FLS 606	Advances in breeding of flower crops	2+1
FLS 607	Advances in production technology of flower crops	2+1
FLS 608	Advances in protected cultivation of flower crops	2+1
FLS 609	Advances in landscape gardening	1+2
	Minor courses	06
	Supporting courses	05
FLS 691	Seminar-I	0+1
FLS 692	Seminar-II	0+1
FLS 699	Research*	0+75
	Total Credits	**114**

SEMESTER WISE LAYOUT FOR Ph.D. (Hort)
FLORICULTURE AND LANDSCAPING

I SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FLS 601*	Crop Regulation in Ornamental Crops	2+1
FLS 602*	Postharvest Biology of Floricultural Crops	2+1
FLS 603	Specialty Flowers, Fillers and Cut Greens	1+1
FLS 604	Biotechnological Approaches in Floricultural Crops	2+1
****Total 8/9 credits will be offered**		
FLS 699	Research	0+3
	Total (A)	**11**
	B) Minor courses	
GPB 601	Advances in plant breeding systems Or other courses from Meteorology /GPB / MBM/ Agril. Economics as per SAC recommendations	3+0
	Total (B)	**3**
	C) Supporting Courses	
	Total (C)	**3**
	D) Non Credit Courses	
	Total (A+B+C+D)	**16**

***Compulsory course**

II SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FLS 605*	Advances in Landscaping	1+1
FLS 606	Advances in breeding of flower crops	2+1
FLS 607	Advances in production technology of flower crops	2+1
FLS 608	Advances in protected cultivation of flower crops	2+1
****Total 5 credits will be offered**		
PSMA -699	Research	0+6
	Total (A)	**11**
	B) Minor courses	
PP 607	Physiological and Molecular Aspects of Source-sinkCapacity for Enhancing Yield or	3+0
AGM 601	Climate change and sustainable development Or	2+1
	other courses from Meteorology /GPB / MBM/ Agril. Economics as per SAC recommendations	
	Total (B)	**3**
	C) Supporting Courses	
AGRON 608	Research and Publication ethics Or	2+0
STAT 604	Advanced statistical methods or	2+1
	other courses from Statistics	
	Total (C)	**2/3**
	D) Non Credit Courses	
	Total (A+B+C+D)	**16/17**

***Compulsory course**

Note: One course should be selected from minor courses.

III SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FLS 691	Seminar-I	0+1
FLS -699	Research	0+16
	Total (A)	**0+17=17**
	B) Minor courses	
GPB 604	Plant genetic recourses , conservation and utilization	2+0
	C) Supporting Courses	
STAT 612	Advanced design of experiments Or other courses from Statistics	**2+1**
	Total (A+B+C+D)	**22**

IV SEMESTER

CourseNo	Course Title	Credit Hours
	A) Major courses	Nil
FLS 692	Seminar II	0+1
FLS -699	Research	0+17
	Total	**18**

V SEMESTER

CourseNo	Course Title	Credit Hours
	A) Major courses	
FLS -699	Research	0+18
	Total	**18**

VI SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
FLS -699	Research	0+15
	Total	**15**

CREDIT LAYOUT FOR Ph.D. (Hort.)
Floriculture and Landscaping

Semester	Major 12	Minor 6	Supporting 5	Seminar	Total
I	9	3	0	0	12
II	5	3	3	0	11
III	0	2	3	1	6
IV	0	0	0	1	1
V	0	0	0	0	0
VI	0	0	0	0	0
Total	14	8	6	2	30

Corse Title: Crop Regulation in Ornamental Crops

Course Code: FLS 601

Credit Hours: (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Basis of crop regulation	
1 -2	Basis of flowering: Ecophysiological influences on growth and development of flower crops for flowering in ornamental crops.	10
2, 3	Crop load and assimilate partitioning and distribution. Root and canopy regulation.	10
3, 4,5	Growth regulators: Study of plant growth regulators including biostimulants and polyamines in floriculture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants.	20
5,6,7	Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition,	10
8,9	Plant architecture management for flower crops and ornamental plants, molecular approaches in crop growth regulation.	10
Block II	Programming	
10,11,12	Growth regulation : Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy, flower bud initiation, regulation of flowering, photo and thermo periodism, off season production, bulb forcing techniques.	20
13,14,15,16,17	Programmed production: Programmed production of important flower crops like chrysanthemum, tulips, lilium, daffodils, poinsettia, kalanchoe, gypsophila.	20

Practical:

P. No.	Practical
1-2	Plant architecture studies in important flower crops
3-6	Bioassay and isolation through chromatographic analysis for auxins, gibberellins, cytokinins, ABA
7-8	Growth regulation during propagation, dormancy, flowering
9-10	Photoperiod regulation in short day and long day crops
11-12	Off season production in important crops
13-14	Bulb forcing in bulbous ornamental crops
15-16	Exposure visits

Suggested Reading

Buchanan B, Gruiessam W and Jones R. 2002. *Biochemistry and Molecular Biology of Plants*. 2015. Wiley Blackwell Publ. 2nd Edition, pp. 1280.

De Hertagh A and Le Nard M. 1993. *The Physiology of Flower Bulbs*. Elsevier, London, UK. Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. John Wiley & Sons. Fosket DE. 1994. *Plant Growth and Development: A Molecular Approach*. Academic Press. pp. 580.

Leoplod AC and Kriedermann PE. 1985. *Plant Growth and Development*. McGraw-Hill, New York. 3rd Edition.

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

Roberts J, Downs S and Parker P. 2002. *Plant Growth Development*: *In Plant*. Oxford University Press. pp. 221-274.

Salisbury FB. and Ross CW. 1992. *Plant Physiology, Hormones and Plant Regulators: Auxins and Gibberellins*. Wadsworth Publ., Belmont. 4th Edition, pp. 357-381.

Course Title: Postharvest Biology of Floricultural Crops
Course Code: FLS 602
Credit Hours : (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Preharvest and post harvest physiology and biochemistry	
1,2	Pre harvest physiology: Maturity indices, harvesting practices for specific market requirements of important flower crops.	05
2,3,4,5,6	Influence of pre-harvest practices, enzymatic and other biochemical changes, respiration, transpiration in important flower crops.	10
7,8,9,10	Senescence: Physiology and biochemistry of flowering, enzymatic changes, Ethylene sensitivity, ethylene evolution and management in important flower crops.	10
11,12,13,14	Factors leading to post-harvest loss, pre-cooling. Petal senescence at molecular level, functional gene analysis for postharvest flower quality in important flower crops, etc.	10
15,16	Pigments and secondary metabolites: Biosynthetic pathways of chlorophyll, xanthophyll, carotenoids, flavonoids and anthocyanins and betalains.	05
17,18	Chemistry and importance of secondary metabolites. Biochemistry and utilization for commercial products in important flower crops.	10
BLOCK II	Storage and packaging	

19,20	Storage of flowers: Treatments prior to shipment, viz., precooling, pulsing, impregnation, chemicals, Irradiation, biocontrol agents and natural plant products.	10
21,22,23	Methods of storage: ventilated, refrigerated, Modified atmosphere, Controlled atmosphere storage, cool chain management, physical injuries and disorders in important flower crops.	10
24,25	Packing : Packing methods and transport, Smart technologies in packaging and storage, advanced tools like nanotechnology application for quality parameters and post harvest treatments for export in important flower crops, packaging standards, flower labels value chain in floriculture.	10
26,27	Recent trends-: Recent trends extraction of bio-colours from flowers- conventional as well as in-vitro methods and their value addition uses in food and textile industries. Molecular techniques for enhancing postharvest flower quality, transgenics in ornamental plants for enhanced postharvest life.	10
28-32	Dried ornamental crops: Post harvest handling of dried ornamental crops including packing, storage and shipment. Storage pest and mould problems in dried ornamental produce, colour retention, physiological and biochemical changes, etc.	10

Practical:

P. No.	Practical
1-2	Improved packaging and storage of important flowers
3-4	Physiological loss in weight of flowers, estimation of transpiration, respiration rate, ethylene release and study of vase life
5	Extension in cut flower vase life using chemicals
6	Estimation of quality characteristics in stored flowers

7-8	Estimation of biochemical changes like enzymatic changes, lipids and electrolyte leakage
9-12	Extraction of flower pigments – Chlorophyll, xanthophylls, carotenoids and anthocyanins
13-14	Cold chain management – visit to cold storage, MA and CA storage units
15-16	Project preparation

Suggested Reading

Buchanan B, Gruiessam W and Jones R. 2002. *Biochemistry and Molecular Biology of Plants*. 2015. Wiley Blackwell Publ. 2nd edition, pp. 1280.

Dey PM and Harborne JB. 1997. *Plant Biochemistry*. Academic Press. 2nd Edition.

Glover MD. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall Publ. Goodwin TW and Mercer EI. 2003. *Introduction to Plant Biochemistry*. CBS Publ

Course Title : Specialty Flowers, Fillers and Cut Greens
Course Code : FLS 603
Credit Hours : (1+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Scope	
1	Importance, national and international scenario: Introduction, present status, scope, importance and avenues for specialty flowers and cut greens.	10
Block II	Avenues	
2-6	Specialty flowers: Cultivation practices of speciality flower crops like heliconia, red ginger, Bird of Paradise, Ornamental banana, ornamental curcuma, gingers, wax flower, kangaroo paw, limonium, rice flower , Statis, larkspur, dusty miller, snapdragon	20
7-8	Fillers: Cultivation practices of fillers like gypsophila, solidago, Mollucella, lupins, etc.	10
9-11	Cut greens: Cultivation practices of cut greens like anthurium, ferns, asparagus, cycas, thuja, bottle brush, ornamental palms, zanado, dracaena, eucalyptus, ruscus, dianella, alpinia, *Murraya exotica* (Kamini)	20
BLOCK III	Trade and Marketing	
12-14	Post harvest management: Pre and post harvest factors influencing the vase life of the flowers and fillers, Post harvest management including pulsing, holding, packing, storing, forward and backward linkages, value chain management.	20
15-16	Standards : Quality standards, Packaging standards, marketing and trade in important flower, filler and foliage	20

	crops.	

Practical:

P. No.	Practical
1-2	Identification of specialty flowers, fillers and cut greens
3-4	Media and bed preparation for cultivation
5-6	Propagation of important crops
7-8	Integrated disease and pest management in important crops
9-10	Post harvest handling of specialty flowers, fillers and cut greens
11-12	Preparation of value added products from important specialty flowers, fillers and foliages
13-14	Exposure visits
15-16	Economics and Project preparation

Suggested Reading

Armitage AM and Laushman JM. 2008. *Speciality Cut Flowers*. Timber Press. 2nd Edition, pp.636.

Bhattacharjee SK. 2006. *Vistas in Floriculture*. Pointer Publ., Jaipur, India.

Bhattacharjee SK and De LC. 2003. *Advanced Commercial Floriculture* Vol.1. Aavishkar Publ. & Distributors, Jaipur India.

Bose TK, Yadav LP, Pal P, Parthasarathy VA and Das P. 2003. *Commercial Flowers*. Vol. I & II. Naya Udyog, Kolkata, India.

Misra RL and Misra S. 2017. *Commercial Ornamental Crops: Traditional and Loose Flowers*. Kruger Brentt Publisher UK Ltd.

Mukherjee D. 2008. *Speciality Cut Flowers-Production Technologies*. Naya Udyog Kolkata, India. pp. 614.

Salunkhe K, Bhatt NR and Desai BB. 2004. *Post harvest Biotechnology of Flowers and Ornamental Plants*. Naya Prokash, Kolkata, India.

Course Title : Biotechnological Approaches in Floricultural Crops

Course Code: FLS 604

Credit Hours: (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Scope of biotechnology	
1-4	Scope of biotechnology :Present status of biotechnology, tools techniques and role in floriculture industry, physical factors and chemical factors influencing the growth and development of plant cell, tissue and organs, cyto-differentiation, organogenesis, somatic embryogenesis in important flower crops.	20
Block II	Cell, tissue and organ culture	
5-9	In-vitro lines for biotic and abiotic stress – Meristem culture for disease elimination, production of haploids through anther and pollen culture – embryo and ovule culture, micrografting, wide hybridization and embryo rescue techniques, construction of somatic hybrids and cybrids, regeneration and characterization of hybrids and cybrids, in-vitro pollination and fertilization, hardening media, techniques and establishment of tissue culture plants in the primary and secondary nursery in important flower crops.	20
Block II	Cell, tissue and organ culture	
10-15	Micro propagation: *In-vitro* lines for biotic and abiotic stress – Meristem culture for disease elimination, production of haploids through anther and pollen culture – embryo and ovule culture, micrografting, wide hybridization and embryo rescue techniques, construction of somatic hybrids and cybrids, regeneration and characterization of hybrids and cybrids, *in-vitro*	10

	pollination and fertilization, hardening media, techniques and establishment of tissue culture plants in the primary and secondary nursery in important flower crops.	
16-19	Somaclonal variation and *in-vitro* conservation: Somoclonal variation and its applications – variability induction through in-vitro mutation, development of cell suspension cultures, types and techniques, Synthetic Seed technology, in-vitro production of secondary metabolites, role of bioreactors in production of secondary metabolites, quantification and quality analysis of secondary metabolites using HPLC/ MS/ GCMS/ in-vitro conservation and cryo-preservation techniques in important flower crops.	10
BLOCK III	Genetic engineering and molecular biology	
20-23	Genetic engineering : Gene cloning, genetic engineering vectors and methods of transformation – electroporation, particle bombardment, Functional gene analysis techniques like PTGS including VIGS in ornamental plants, Agrobacterium mediated, transgenic plants in flower crops, Biosafety of transgenics isolation of DNA, RNA, quantification, Polymerase Chain Reaction for amplification; AGE and PAGE techniques; identification of molecular markers in important flower crops.	20
24-27	Molecular approaches: Molecular markers as a tool for analysis of genetic relatedness and selection in ornamental crops. Molecular control of flower development, light sensing with respect to plant development, flower pigmentation, fragrance, senescence, ethylene synthesis pathway in important flower crops. Molecular biology- Gene isolation, characterization, manipulation and transfer in important flower crops.	10

28-32	Construction of c- DNA library, DNA fingerprinting technique in economic flower crop varieties, RNAi, Genome editing basics, molecular approaches to control ethylene response, Fragrance, Plant Architecture, desirable flower traits, colour, shape, improving postharvest life, improving resistance for environmental stress, approaches to improve flower development, pigment production, secondary metabolite production, post harvest biotechnology of flowers, ornamental plants, achievements of bio-technology in flower crops.	10

Practical:

P. No.	Practical
1-2	Micro propagation, Pollen- Ovule and Embryo culture- Synthetic seed production
3-5	*In-vitro* mutation induction, *in-vitro* rooting – hardening at primary and secondary nurseries
6-7	DNA isolation from economic flower crop varieties – Quantification and amplification
8-9	DNA and Protein profiling – molecular markers, PCR Handling
10-12	Vectors for cloning and particle bombardment
13-15	DNA fingerprinting of flower crop varieties
16	Project preparation for establishment of low, medium and high cost tissue culture laboratories

Suggested Reading

Chopra VL and Nasim A. 1990. *Genetic Engineering and Biotechnology-Concepts, Methods and Applications*. Oxford & IBH Publ. Company, USA. pp. 200.

Debnath M. 2011. *Tools and Techniques of Biotechnology*. Pointer Publ.

Glover MD. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall Publ. Gorden H and Rubsell S. 1960. *Hormones and Cell Culture*. AB Book Publ.

Keshavachandran R, Nazeem PA, Girija D, John PS and Peter KV. 2007. *Recent Trends in Horticultural Biotechnology*. Vols. I & II, 1018 p. New India Publ. Agency, New Delhi, India.

Keshavachandran R and Peter KV. 2008. *Plant Biotechnology: Methods in Tissue Culture and Gene Transfer*. Orient Blackswan. 312 p.

Course Title: Vertical Gardening
Course Code: FLS 605
Credit Hours: (1+2)

Theory:

Lecture No /Unit No	Topics	Weig-htage (%)
Block I	Importance	
1-2	Scope: Present status of vertical gardening, benefits of vertical gardening, History of vertical gardens, role of indoor plants in mitigating pollution.	10
3-4	Growth: Factors influencing the growth and development of the plants including light, humidity, temperature, nutrition, irrigation, growth regulation.	10
5,6	Making of vertical gardens: Containers, media, frames, cost effective components, cables, wires, nets for the vertical formations, modular living walls.	20
Block II	Green roofing	
7-10	Green Facades: Influence of green facades in providing thermal comfort, atmospheric cleansing and related environmental benefits, Energy saving potential of green façades, Aesthetic appeal of green structures and other relevant studies on urban greening.	20
11-13	Mitigation of pollution: Plants suitable, Dust mitigation, Radiation absorption, Pollution mitigation, Acoustic attributes of urban greening.	20
14-16	Maintenance: Lifecycle, maintenance, Plants with low light, medium, high intensity requirement, cost effectiveness and overall sustainability of living walls.	20

Practical

P. No.	Practical
1-6	Identification of plants
7-10	Components of vertical gardens
11-15	Designing of vertical gardens for different locations
16-20	Maintenance of vertical gardens
21-24	Economics
25-28	Project preparation
29-32	Exposure visit

Suggested Reading

Aihog Li. 2019. Vertical garden design : A comprehensive Guide, Systems, Plants and case studies. Artpower International.

Bhattacharjiee S. K. 2004: Landscape gardening and design with plants Aavishkar Publishers, Distributors

Course Title: Advances in Breeding of Flower Crops
Course Code: FLS 606
Credit Hours: (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	***In-vitro* techniques and biosynthetic pathways**	
1-4	*In-vitro* techniques: Role of biotechnology in improvement of flower crops; *in-vitro* mutagenesis, embryo culture, somaclonal variation, transformation	10
5-8	*in-vitro* cryopreservation, somatic hybridization, anther and ovule culture including somatic embryogenesis	10
9-12	Biosynthetic pathways: Biosynthetic pathways of pigment, fragrance and senescence, flower form; chemistry	10
13-16	Importance of secondary metabolites, genomics, proteomics, metabolomics	10
Block II	Molecular techniques	
17-20	Molecular breeding: Molecular breeding and Marker assisted selection; molecular characterization;	15
21-24	Construction of c-DNA library; High throughput sequencing.	10
25-28	nome editing: Genome editing, CRISPER CAS, gene pyramiding, allele mining.	15
29-30	Advances in flower crops: Breeding for biotic and abiotic stresses using biotechnological means; designer flower crops.	10
31-32	Advancements in important flower crops like rose, chrysanthemum, carnation, orchids, anthuriums, lilium, gerbera, etc.	10

Practical:

P. No.	Practical
1-2	*In-vitro* mutagenesis, embryo culture, somaclonal variation
3-4	Somatic hybridization, anther and ovule culture and somatic embryogenesis
5-6	Genetic transformation
7-10	Genetic fingerprinting, Genome editing techniques
11-12	PCR, genomics, blotting techniques
13-14	Cloning, marker assisted selection
15-16	Bioinformatics

Suggested Reading

Anderson NO. 2007. *Flower Breeding and Genetics Issues, Challenges and Opportunities for the 21st Century*. Springer Publ., The Netherlands.

Arthur ML. 2013. *Introduction to Bioinformatics*. Oxford University Press, U.K. 400 p. Chadha KL and Chaudhury B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.

Nelson DL and Cox MM. 2000. *Principles of Biochemistry*. 4th Edition, Lehninger Publ. Panopoulas NJ (Ed.). 1981. *Genetic Engineering in Plant Sciences*. Praeger Publ.

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

Pierik RLM. 1987. *In-vitro Culture of Higher Plants*. MartinusNijhoff Publ. Amsterdam. Primrose SB and Twyman R. 2006. *Principles of*

Gene manipulation and Genomics. Blackwell Publ., USA.

Srivastava PS, Narula A and Srivastava S. 2005. *Plant Biotechnology and Molecular Markers*. Anamaya Publ., New Delhi, India.

Vainstein A. (Ed.) 2002. *Breeding for Ornamental crops: Classical and Molecular Approaches*. Springer-Science-Business Media, B.V. 1st Edition.

Wilson K and Walker J. 2010. *Principles and Techniques of Biochemistry and Molecular Biology*. 7th Edition, Cambridge University Press, UK.

Course Title : Advances in Production Technology of Floricultural Crops
Course Code : FLS 607
Credit Hours : (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Production technology	
1-2	Scope and importance: Commercial flower production; Scope and importance; Global Scenario in cut flower production and trade	05
3-4	Varietal wealth and diversity; Soil and Environment; cut flower, loose flowers, dry flowers and essential oil trade, flower seed production	05
5-6	Special characteristics and requirements. Essential oil industry, recent advances in extraction methods.	05
7-8	Cultural operations Propagation and multiplication	05
9-12	Greenhouse management; Soil/ media decontamination techniques; Microirrigation; nutrition and fertigation; slow release fertilizers and biofertilizers; influence of environmental parameters, light, temperature, moisture, humidity and CO_2 on growth and flowering.	10
13-18	Crop Regulation: Flower forcing and year-round flowering through physiological interventions; Chemical regulation; Environmental manipulation, important insect pests, diseases, nematodes and their management through IPM and IDM, quarantine measures for export and other export norms.	10

19-24	Advances in roses, chrysanthemum, carnation, tuberose, gladiolus, lilum, gerbera, orchids, anthuriums, etc.	20
25-26	Natural and Organic Farming Approaches in Flower Crops	10
Block II	Mechanization and Post harvest management	
27-29	Mechanization : Mechanization, automation, ICT and AI in floriculture.	10
30-32	Post harvest management: Harvest indices, Harvesting techniques; Post harvest handling for local, distant and export market, Cluster production, Contract farming, FPOs, Value chain management.	20

Practical:

P. No.	Practical
1-2	Greenhouse management; Soil decontamination techniques
3-4	Microirrigation; Nutrition and fertigation
5-6	Special practices- bending, netting, pinching, disbudding, defoliation and chemical pruning, etc.
7-8	Photoperiodic and chemical induction of flowering
9-10	Assessing harvest indices; Post-harvest handling
11-12	Case studies
13-16	Visit to commercial cut flower and essential oil units

Suggested Reading

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

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

George S and Peter KV. 2008. *Plants in a Garden*. New India Publ.

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

Misra RL and Misra S. 2017. *Commercial Ornamental Crops: Traditional and Loose Flowers*. Kruger Brentt Publisher UK Ltd.

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.

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

Singh AK. 2014. *Breeding and Biotechnology of Flowers, Vol.1: Commercial Flowers*. New India Publ. Agency, New Delhi, India. pp.740.

Course Title : Advances in Protected Cultivation of Flower Crops
Course Code : FLS 608
Credit Hours : (2+1)

Theory:

Lecture No /Unit No	Topics	Weightage (%)
Block I	Production technology	
1-4	Scope and scenario: Prospects of protected floriculture in India, growing structures, basic considerations in establishment and operation of green houses, functioning and maintenance.	10
5-6	Global trade, forward and backward linkages for import clusters, International and national auction houses.	10
7-8	Micro climate management :Environmental control systems in greenhouse, regulation of light through LEDs containers, substrate culture, soil decontamination techniques, aeroponics, hydroponics and vertical farming.	10
9-19	Cultural operations: Water and nutrient management, crop regulation, special horticultural practices under protected cultivation of rose, chrysanthemum, carnation, orchids, anthurium, gerbera, lilium, cut foliage and potted ornamental crops; plant architecture management in ornamental plants.	20
20-26	Advances in flower crops: Advances in protected cultivation of important flowering (rose, chrysanthemum, carnation, gerbera, orchids, anthurium, lilium, and foliage plants (agloenema, monstera, dracaena, syngonium, pothos, diffenbachia, etc.)	20
Block II	Precision floriculture and regulations	

27-29	Precision floriculture : Precision floriculture, Principles and concepts, enabling technologies of precision floriculture, remote sensing, sensors, automation in greenhouses, solar greenhouses, retractable greenhouses. Computers and robotics, decision support systems, apps, cold chain management, use of AI for production and trade.	20
30-32	Regulations: PBR/ IPR issues; Forward and backward linkages, 100% EOU, packaging and export standards, Cool chain Management, non-tariff barriers, APEDA regulations for exports, marketing channels, auction houses, major markets.	10

Practical:

P. No.	Practical
1-2	Growing structures, basic considerations in establishment and operation of greenhouses;
3-4	Environmental control systems in greenhouse;
5-6	Containers, substrate culture, soil decontamination techniques;
7-8	Crop regulation;
9-12	Special horticultural practices under protected cultivation;
13-14	Precision equipments, computers and robotics in precision farming;
15	Harvest indices – harvesting, Post harvest handling, marketing;
16	Export and cold chain management.

Suggested Reading

Bhattacharjee SK. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.Reprint, 2065 p.

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

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

Course Title : Advances in Landscape Gardening
Course Code : FLS 609
Credit Hours : (1+2)

Theory:

Lecture No /Unit No	Topics	Weigh tage (%)
1-3	Landscape design: Commercial landscape gardening- History, Plant identification and ecology, Materials of garden design, Design making by different garden styles and types. Design principles in ancient and modern landscape. Principles of designing a commercial landscape project.	20
4-6	Role of landscaping in environment improvement, ecology conservation (birds, butterflies, animals). Plant wealth for edges, hedges, herbaceous borders, trees, floral beds, water plants, cacti, ferns, palms, etc.	20
7-10	Site analysis: Assessing site and plants adaptability for different locations, Landscape engineering (Topographical survey and designing concept including GIS,GPS, Remote sensing), special techniques in garden landscaping (Burlapping, waterscaping, xeriscaping, hardscaping, lawn establishment, topiary styles specializing, bioaesthetic planning).	20
11-12	Software in landscaping: Preparation and drawing of site plan, Learning the basics in computer aided design (CAD) for developing a garden landscape plan, Handling soft landscape materials (AUTOCAD and ARCHICAD), GIS as a tool for spatial designing.	10
13-14	Landscaping for different situations : Contemporary landscaping, Urban landscaping, Environmental landscaping, Industrial and institutional landscaping, Public and private garden making, play ground landscaping, Inventory management, Landscape restoration, Assessing a successful design in site.	20

15-16	Maintenance: Maintenance of different types of gardens, waste water utilisation, historical and archaeological garden sites, Permissions required for bigger projects, carbon sequestration, carbon credits etc.	10

Practical:

P. No.	Practical
1	Plant identification
2-3	Materials of garden design, Design making by different garden styles and types
4-5	Assessing site and plants adaptability for different locations
6-9	Way of designing a commercial landscape project
10-11	Landscape engineering (Topographical survey and designing concept)
12-15	Preparation and drawing of site plan
16-19	Learning the basics in computer aided design (CAD) for developing a garden landscape plan
20-23	Handling soft landscape materials (AUTOCAD and ARCHICAD), GIS as a tool for spatial designing
24-27	Case study with the successful landscapist
28-29	Budget/ Project cost estimating
30-32	Exposure visits

Suggested Reading

Aihog Li. 2019. Vertical garden design : A comprehensive Guide, Systems, Plants and case studies. Artpower International.

Bhattacharjiee S. K. 2004: Landscape gardening and design with plants Aavishkar Publishers, Distributors

Suggested Journals

Sr. No.	*Name of the Journal*	ISSN No.
1	*Annals of Horticulture*	0976-4623
2	*Biological Agriculture and Horticulture*	2165-0616
3	*Current Horticulture*	2455-7560
4	*European Journal of Medicinal Plants*	2231-0894
5	*Horticulture Enviornment and Biotechnology*	2211-3460
6	*Indian Coconut Journal*	0970-0579
7	*Indian Horticulture Journal*	2347-3029
8	*Indian Journal of Arecaunt Spices and Medicinal Plant*	0972-2483
9	*Indian Journal of Arid Horticulture*	2249-5258
10	*Indian Journal of Horticulture*	0974-0112
11	*International Journal of Horticulture*	1927-5803
12	*International Journal of Horticulture, Agriculture and Plant Sciences*	2572-3154
13	*International Journal of Innovative Horticulture*	2320-0286
14	*International Journal of Tea Science*	0972-544
15	*Journal of Applied Horticulture*	0972-1045
16	*Journal of Herbs, Spices, and Medicinal Plants*	1540-3580
17	*Journal of Medicinal and Aromatic Plant Sciences*	0253-7125
18	*Journal of Medicinal Food*	1557-7600
19	*Journal of Medicinal Plant Research*	1996-0875
20	*Journal of Medicinal Plant Studies*	2320-3862
21	*Journal of Plantation Crops*	2454-8480
22	*Journal of Spices and Aromatic Crops*	0971-3328
23	*Medicinal Plants: International Journal of Phytomedicines and Related*	0975-4261
24	*Polycyclic Aromatic Compounds*	1040-6638
25	*Progressive Horticulture*	2249-5258
26	*Rubber Science (Natural Rubber Research)*	2524-3993
27	*Spice India*	0970-5805
28	*The Asian Journal of Horticulture*	0973-4767

Restructured and Revised Syllabus

Horticultural Sciences

M.Sc. & Ph. D. (Horticulture)

in

Plantation, Spices, Medicinal and Aromatic Crops

Submitted by

Broad Subject Coordinator
Associate Dean
College of Horticulture,
Dr. BSKKV, Dapoli

Discipline Coordinator
Prof. of Horticulture,
College of Horticulture,
Dr. BSKKV, Dapoli

CONTENTS

A COMMITTEE HAS BEEN CONSTITUTED FOR REVISION OF THEPG SYLLABUS FOR PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS WIDE NO. DBSKKV/ 100 DICC/PGSYLLABI/732/22 DATED- 11 MARCH 2022 IN 100 TH DICC MEETING.

Discipline	**Degree Programme**		**Broad Subject Coordinator (Chairman of PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS Discipline)**	**Discipline Coordinator (Secretary of PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS Discipline)**
Plantation, Spices, Medicinal and Aromatic Crops	**M.Sc.**	**Ph.D.**	Dr. R. G. Khandekar Professor, CoH, Dr. BSKKV, DAPOLI.	Dr. G. M.Waghmare Head (FS), VNMKV, Parbhani
				Dr. V. S. Kale Member & Professor, Department of Vegetable Science, PDKV, Akola
				Dr. D. B. Kshirsagar, Member & Associate Professor Department of Horticulture, MPKV, Rahuri

1. GENERAL INTRODUCTION

Horticulture crops occupy only 8.5 per cent of areable land; they contribute 25.5 per cent of the Agriculture GDP. Plantation crops especially tea, coffee and rubber crops just occupying 0.95 per cent to of cropped area have stake of 15.1 per cent of the total expert earnings of agricultural produce. Therefore, the country has considered horticultural and plantation sector as the growth engine of Agricultural economy. Over last decades, the area under horticultural crops grew by about 3 per cent per annum with increase in annual production by 5.4 per cent and the share of horticulture output in agriculture being more than 33 percent.

It became independent college, subsequently, in several SAU's. At present, the discipline of PSMA has been further bifurcated up to four departments in may agri-horticultural universities in the country. The BSMA constituted by the ICAR vide OO. No.F.No.13(1)/2007-EQR dated January 14, 2008 under Chairmanship of Dr K.V. Peter, Former Vice-Chancellor, formulated the common PG Syllabus for Horticulture discipline for the first time and recommended for implementation of the same uniformly throughout the country. The document was published by the ICAR during April 2009. The said committee, considered four disciplines in horticulture science, viz., Fruit science, Vegetable Science, Floriculture and Landscape Architecture and **Plantation, Spices, Medicinal and Aromatic Crops,** instead of one composite discipline, viz., Horticulture. The ICAR in its O.O.F.No.7/6/2017 EQR dt: 04.04.2018 has constituted 19 BSMA Committees based on the National Core Group recommendations to look into various issues related to PG Programmes.

2. Implementation of New Curriculum

The universities offering PG programmes in PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS need to be supported for establishing specialized laboratories equipped with state of the art equipment's for conducting practical classes. One-time catch-up grant should be awarded to each SAU, offering PG programmes in PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS for meeting expenditure for upgrading the course requirements.

Faculty training and retraining should be an integral component. To execute the new PG programmes in PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS in effective manner, special funds from ICAR would be required for outsourcing of faculty from Indian/Foreign Universities for some initial years.

Expected Outcome

- Revamping of post graduate programme in whole of Plantation, Spices, Medicinal And Aromatic Crops throughout the country.
- Imparting quality education.
- Development of technical manpower to cater the need of governments, corporate sector and research organization in India and abroad. Exposure to the faculty in the latest technical knowhow.

3. CREDIT REQUIREMENTS

Courses	Masters' Programme	Doctoral Programme
(i) Course work		
Major Courses	20	12
Minor Courses	08	06
Supporting Course(s)	06	05
Common compulsory courses	05	-
Seminar	01	02
(ii) Comprehensive Exam	-	Non-credit course
(iii) Thesis/ Research	30	75
Total	**70**	**100**

4. SUPPORTING COURSES

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Statistic
2. Agronomy
3. Soil Science
4. Biochemistry
5. Organic Farming
6. Forestry
7. Plant Pathology
8. Plant Physiology
9. Entomology
10. Computer Science and Information Technology

Supporting Courses- Suggestive list of Supporting Courses

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
FPU 506	Agro-techniques of Medicinal and Aromatic Crops	2+1
FPU 508	Chemistry and Processing of Medicinal and Aromatic Plants	2+1
FPU 514	Production of Medicinal and Aromatic Crops	1+1

5. COMPULSORY NON-CREDIT PGS COURSES

Course code	Course Title	Credit Hours
PGS-501	Library and Information Services	0+1
PGS-502	Technical Writing and Communications Skills	0+1
PGS-503	Intellectual Property and its Management in Agriculture	1+0
PGS-504	Basic Concepts in Laboratory Techniques	0+1
PGS-505	Agricultural Research, Research Ethics and rural development programme.	1+0

6. Minor Courses from other Discipline for M.Sc.Courses & Credit Requirements

1. Genetics and Plant Breeding
2. Seed Science and Technology
3. Plant Physiology
4. Fruit Science
5. Agronomy
6. Agricultural Statistics
7. Biochemistry
8. Soil Science
9. Floriculture and Landscaping
10. Plantation, Spices, Medicinal and Aromatic Crops
11. Post-harvest Management

Note: These are the minor disciplines for M.Sc. Students; however some suggestive minor courses included in semester wise layout.

Minor Courses- Suggestive list of minor courses

Department	Course No	Course Title	Credits
Genetics And Plant Breeding	GPB 502	Principles of Plant Breeding	(2+1)
	GPB 514	Breeding Fruit Crops	(2+1)
Plant Physiology	PP 501	Principles of Plant Physiology-I: Plant Water Relations and Mineral Nutrition	(2+1)

	PP 502	Principles of Plant Physiology-II: Metabolic Processes and Growth Regulation	(2+1)
	PP 503	Plant Developmental Biology: Physiological and Molecular Basis	(2+1)
	PP 510	Seed Physiology	(2+1)
Agronomy	AGRON 501	Modern Concepts in Crop Production	(3+0)
	AGRON 502	Principles and practices of soil fertility	(2+1)
	AGRON 503	Principles and Practices of Weed Management	(2+1)
	AGRON 504	Principles and Practices of Water Management	(2+1)
	AGRON 505	Agrometeorology and weather forecasting	(2+1)
Soil Science	Soil 501	Soil physics	(2+1)
	Soil 502	Soil fertility and fertilizer use	(2+1)
	Soil 503	Soil chemistry	(2+1)
	Soil 504	Soil mineralogy, genesis and classification	(2+1)
Fruit Science	FSC-501	Tropical fruit production	(2+1)
	FSC 502	Subtropical 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 507	Growth and Development of Fruit Crops	(2+1)
Vegetable Science	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	(2+1)
Floriculture and Landscaping	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)
Plant Pathology	PL PATH 501	Mycology	(2+1)
	PL PATH 502	Plant Virology	(2+1)
	PL PATH 503	Plant Pathogenic Prokaryotes	(2+1)
	PL PATH 504	Plant Nematology	(2+1)
	PL PATH 505	Principles of Plant Pathology	(2+1)
	PL PATH 506	Techniques in Detection and Diagnosis of plant Diseases	(0+2)
	PL PATH 515	Diseases of Field and Medicinal Crops	(2+1)

Note: Other than above courses student may select required courses with the permission of SAC

7. Minor Courses from other Disciplines for Ph.D.- Course Structure & Credit Requirements

Department	Course No	Course Title	Credit
Fruit Science	FSC 601	Innovative Approaches in Fruit Breeding	3+0
	FSC 602	Modern Trends in Fruit Production	3+0
Vegetable science	VSC 601	Recent Trends in Vegetable Production	3+0
	VSC 602	Advances in Breeding of Vegetable Crops	3+0
Floriculture and landscaping	FLS 601	Crop Regulation in Ornamental Crops	1+1
	FLS 602	Postharvest Biology of Floricultural Crops	2+1
	FLS 605	Advances in Landscaping	1+1
Genetics and Plant Breeding	GPB 601	Advances in Plant Breeding Systems	3+0
	GPB 605	Genomics in Plant Breeding	3+0
	GPB 609	IPR and Regulatory Mechanism (e-course)	1+0
Plant Physiology	PP 602	Signal Perceptions and Transduction and Regulation of Physiological Processes	2+0
	PP 607	Physiological and Molecular Aspects of Source-sink Capacity for Enhancing Yield	3+0
Biochemistry	BIOCHEM 603	Biochemistry Of Biotic And Abiotic Stresses	3+0
Soil Science	SOIL 606	Soil resource management	3+0
Agronomy	AGRON 601	Current trends in Agronomy	3+0
	AGRON 608	Research and Publication ethics	2+0
Soil Science	SOIL 603	Physical chemistry of soil	2+0
	SOIL 604	Soil genesis and micromorphology	2+0
Plant pathology	PL PATH 604	Molecular Basis of Host-pathogen Interaction	2+1
Entomology	ENT 605	Bio-inputs for Pest Management	2+1

Note: Other than above courses student may select required courses with the permission of SAC

8. ORGANIZATION OF COURSE CONTENTS

8.1. Minimum Residential Requirement:

P.G. Degree Programmes		
	Minimum	**Maximum**
Masters' Degree	2 Academic Years	5 Academic Years
	(4 Semesters)	(10 Semesters)
Ph.D.*	Academic Years (6 Semesters)	7 Academic Years (14 Semesters)

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

8.2. Nomenclature of Degree Programme

(a) M.Sc. (Hort.) PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

(b) Ph.D. (Hort.) PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

8.3. Code Numbers

- All courses are divided into two series: 500-series courses pertain to Master's level, and 600- series to Doctoral level.
- Credit Seminar for Master's level is designated by code no. 591, and the Two Seminars forDoctoral level are coded as 691 and 692, respectively
- Deficiency courses will be of 400 series.
- Master's research: 599 and Doctoral research: 699

8.4. Course Contents

The contents of each course have been organized into:

- Objective – to elucidate the basic purpose.
- Theory units – to facilitate uniform coverage of syllabus for paper setting.
- Suggested Readings – to recommend some standard books as reference material. This does not obviously exclude such a reference material that may be recommended according to the advancement and local requirement.
- A list of international and national reputed journals pertaining to the discipline is providedat the end which may be useful as study material for 600/700 series courses as well as research topics.
- Lecture schedule and practical schedule has also be given at the end of each course to facilitate the teacher to complete the course in an effective manner.

9. SEMESTER WISE LAYOUT FOR M. Sc. (Hort.) in PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

I SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
PSMA 501*	Production of Plantation Crops	2+1
PSMA 502*	Production of Spice Crops	2+1
PSMA 508	Underexploited Plantation, Spice, Medicinal and aromatic crops	2+0
	Total (A)	**6+2=8**
	B) Minor courses	
FSC-501	Tropical fruit production	2+1
PP 501	Principles of Plant Physiology-I: Plant Water Relations and Mineral Nutrition	2+1
	Total (B)	**4+2=6**
	C) Supporting Courses	
STAT 502	Statistical Methods for Applied Sciences	3+1
	Total (C)	**4**
	Total (A+B+C)	**18**
	D) Non Credit Courses	
PGS 501	Library and Information Services	0+1
PGS 504	Basic Concept in Laboratory Techniques	0+1
	Total (D)	**2**
	Total (A+B+C+D)	**20**

***Compulsory course**

Note: One course should be selected from non compulsory courses.

II SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
PSMA 503*	Production of Medicinal and Aromatic Crops	2+1
PSMA 504*	Breeding of Plantation and Spice Crops	2+1
PSMA 509	Growth and Development of Plantation, Spice, Medicinal	2+1
	Total (A)	**6+3 = 9**

	B) Minor courses	
VSC 502	Production of Warm Season Vegetable Crops	2+1
	Total (B)	**3**
	C) Supporting Courses	
STAT 511	Experimental Designs	2+1
	Total (C)	**3**
	Total(A+B+C)	**15**
	D) Non Credit Courses	
PGS 502	Technical Writing and Communication Skill	0+1
PGS 503	Intellectual Property and its Management in Agriculture	1+0
	Total (D)	**2**
	Total(A+B+C+D)	**17**

***Compulsory course**

III SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
PSMA 505*	Breeding of Medicinal and Aromatic Crops	1+1
PSMA 511	Biodiversity and Conservation of Plantation, Spice, Medicinal and Aromatic Crops	2+1
PSMA 599	Research	0+12
	Total (A)	**3+14=17**
	B) Minor courses	**NIL**
	C) Supporting Courses	**NIL**
	D) Non Credit Courses	
PGS 505	Agricultural Research, Research Ethics and Rural Development Programme	1+0
	Total (D)	**1**
	Total	**18**

***Compulsory course**

IV SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
PSMA 591	Seminar	0+1
	Total (A)	**1**
Research		
PSMA 599	Research	0+18
	Total Research Credit	**18**
	Total	**19**

Remedial Non Gradial compulsory Courses

Deficiency courses:
Make up courses for B. Sc. (Agriculture) Students seeking admission for M.Sc. (Hort.) PSMA

Sr. No.	Course No.	Title	Credits
1	H/SPICON 231	Spices and condiments	1+1=2
2	H/AROMED 241	Aromatic and Medicinal plants	1+1=2
3	H/FS 242	Breeding of fruits and plantation crops	2+1=3

Deficiency courses:

Make up courses for B. Sc. (Forestry) Students seeking admission for M.Sc. (Hort.) PSMA

Sr. No.	Course No.	Title	Credits
1	H/SPICON 231	Spices and condiments	1+1=2
2	H/AROMED 241	Aromatic and Medicinal plants	1+1=2
3	H/FS 242	Breeding of fruits and plantation crops	2+1=3
4	H/FS 354	Temperate fruits and plantation crops	2+1=3

10. M.Sc. PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS COURSE STRUCTURE AND COURSE CONTENT

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)	
PSMA 501*	Production of Plantation Crops	2+1
PSMA 502*	Production of Spice Crops	2+1
PSMA 503*	Production of Medicinal and Aromatic Crops	2+1
PSMA 504*	Breeding of Plantation and Spice Crops	2+1
PSMA 505*	Breeding of Medicinal and Aromatic Crops	1+1
PSMA 506	Systematics of Plantation and Spice Crops	1+1
PSMA 507	Systematics of Medicinal and Aromatic Crops	1+1
PSMA 508	Underexploited Plantation, Spice, Medicinal and aromatic crops	2+0
PSMA 509	Growth and Development of Plantation, Spice, Medicinal	2+1
PSMA 510	Biochemistry of Plantation, Spice, Medicinal and	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 Title : Production of Plantation Crops
Course Code : PSMA 501
Credit Hours : (2+1)
Theory:

Block / Lec. No.	Topic	
Block-1	**Importance 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. EXport potential: EXPORT potential, problems and prospects and IPR issues in plantation crops. Promotional programmes: Role of commodity boards and directorates in the development programmes of plantation crops	
Block-2	**Production Technology** Varietal wealth: Botany, TaXonomy, species, cultivars and improved varieties in plantation crops. Propagation and nursery management: Plant multiplication including *in-vitro* multiplication, nursery techniques and nursery management in plantation crops. New nursery techniques for production of healthy planting material. Use of media, use of bio regulators, soil less media, propagation structures, mist chambers etc. 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. Certification and GAP in plantation crops. Effect of climate change and their mitigation technology on production of plantation crops.	
Block-3	**Harvest and Post harvest management** Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons and mechanized harvesting in plantation crops. Post harvest management: Post harvest handling including primary processing, grading, packaging, storage and benefit cost analysis of plantation crops. Exposure to various processing machineries used in processing of plantation crops and value added products, marketing.	
Lecture No.	**Topic**	**Weightage**
1-3	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. EXport potential: EXport potential, problems and prospects and IPR issues in plantation crops. Promotional programmes: Role of commodity boards and directorates in the development programmes of plantation crops	10

3-7	Coconut	15
8-10	Arecanut	15
11-13	Cashew	15
14-16	Coffee	10
18-20	Tea	10
21-23	Cocoa	5
24-26	Rubber	5
27-28	Oil palm	5
29-30	Palmyrah	5
31-32	Betel vine	5

Practical:

Practical No.	Topic
1-2	Description of botanical and varietal features of plantation crops
3	Selection of mother palms and seedlings of plantation crops
4-6	Nursery techniques of plantation crops
7-8	Soil and water conservation measures in plantation crops
9	Nutrient deficiency symptoms of plantation crops
10	Manuring practices for plantation crops
11	Pruning and training methods, GAP in plantation crops;
12	Maturity standards of plantation crops
13-14	Harvesting; Processing of plantation crops and value added products of plantation crops
15	Project preparation for establishing plantations;
16	Exposure visits to commercial plantations, research institutes

I. 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 o*

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.* grotech 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.

Course Title : Production of spice crops.
Course Code : PSMA 502
Credit Hours : (2+1)

Theory:

Block / Lec. No.	Topic
Block-1	**Importance of spice crops** 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. Classification of spice crops: Major spices, minor spices, seed spices, tree spices, herbal spices.
Block-2	**Production Technology** Varietal wealth: Botany and taxonomy, species, cultivars, commercial varieties/ hybrids in spice crops. Propagation and nursery management: Seed, vegetative and micro- propagation methods, nursery techniques and nursery management practices. New nursery techniques for production of healthy planting material. Use of media, use of bio regulators, soil less media, propagation structures, mist chambers etc. 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. Certification and GAP in plantation crops. Organic production of spices.
Block-3	**Harvest and Post harvest management** Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons, mechanized harvesting. Post harvest management: Post harvest management including primary processing, grading, packaging and storage, GMP in major spice crops. Exposure to various processing machineries used in processing of plantation crops and value added products, marketing.

Lecture No.	Topic	Weightage
1-3	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. Classification of spice crops: Major spices, minor spices, seed spices, tree spices, herbal spices.	10
Production Technology Harvest and Post harvest management of		
3-6	Black pepper	10
7-8	Nutmeg,	5
9-10	Cinnamon	5
11	Clove, Allspice	5
12-14	Small and large Cardamom	5
15-16	Turmeric, Red chilli	10

17-18	Ginger	10
19-20	Garlic	5
21-22	Coriander, Fenugreek	10
23-24	Cumin, Fennel, Ajwain, Dill	5
25-26	Saffron, Vanilla	5
27-28	Tamarind,	5
29-30	*Zanthoxylum rhetsa* (Triphal), Aniseed	5
31-32	Garcinia	5

Practical:

Practical No.	Topic
1-2	Botanical description of Spice crops
3-5	Identification of seeds and plants of Spice crops
6-7	Varietal features of Spice crops
8-10	Planting material production in Spice crops
11	Field layout and method of planting; Cultural practices; GAP in spice crops; GMP in spice crops
12-14	Harvest maturity, harvesting; Processing of spice crops and value added products; Drying, storage, packaging; Primary processing of spices
15	Short term experiments on spice crops;
16	Exposure visits to spice farms, research institutes.

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.

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Pruthi JS. Ed. 1998. *Spices and Condiments.* National Book Trust.

Pruthi JS. 2001. *Minor Spices and Condiments- Crop Management and Post Harvest Technology*. ICAR.

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Ravindran PN. 2000. *Black pepper, Piper nigrum*. CRC press. 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 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.

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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.

Course Title : Production of Medicinal and Aromatic Crops
Course Code : PSMA 503
Credit Hours : (2+1)

Theory:

Block / Lec. No.	Topic	
Block-1	. **Importance of Medicinal and Aromatic Crops** 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. 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. History and advancements. 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** Varietal wealth: Botany and taXonomy, species, cultivars, commercial varieties/ hybrids in medicinal and aromatic crops. Propagation and nursery management: Seed, vegetative and micro- propagation methods, nursery techniques and nursery management practices. 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. Organic farming of Medicinal and Aromatic Crops	
Block-3	**Harvest and Post harvest management** Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons in medicinal and aromatic crops. Post harvest management: Post harvest management including primary processing, eXtraction, grading, packaging and storage, GMP in medicinal and aromatic crops.	
Lecture No.	**Topic**	**Weightage**
1-3	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. Medicinal and plant based industry: Indian system of	10

	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. History and advancements. 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.	
	Production Technology Harvest and Post harvest management Of	
3-6	Senna, Periwinkle, Gulwel	10
7-8	Aswagandha,, *Dioscorea* sp	10
9-10	Sarpagandha, Medicinal Solanum	10
11	Isabgol, Opium Poppy	5
12-14	*Aloe vera*, *Digitalis (Foxglove)* Safed musli	5
15-16	*Andrographis paniculata (*Kalmegh*)*, Glory Lily, Medicinal Coleus	5
17-18	*Stevia rebaudiana (*Candy leaf), *Mucuna pruriens* (Cowitch Velvet bean), *Piper longum* (Indian long pepper)	5
19-20	*Plumbago zeylanica* (Ceylon leadwort), Hops, Phyllanthus etc.	5
21-22	Palmarosa, Lemongrass. Citronella	10
23-24	Vetiver,, Mentha	5
25-26	Patchouli, Sweet Flag	5
27-28	Jasmine, Scented Rose, Geranium, Artemisia, Lavender	5
29-30	*Ocimum* sp., Eucalyptus, Sandal, Michellia, Rosemary	5
31-32	Thyme, Marjoram, Oreganum etc.	5

Practical:

Practicals No.	Topic
1-2	Description of botanical and varietal features
3-5	Nursery techniques
6-7	Lay out and planting; Manuring practices
8-12	Maturity standards; Harvesting; Primary processing; Extraction of oils Project preparation for establishing herbal gardens and oil extraction
13	Herbarium preparation
14-15	GAP and GMP in medicinal and aromatic crops
16	Exposure visits to institutes, herbal gardens and industries

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.

Kurian A and Asha Sankar M. 2007. *Medicinal Plants.* Horticulture Science Series, New India Publ. Agency.

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.

Course Title : Breeding of Plantation and Spice Crops
Course Code : PSMA 504
Credit Hours : (2+1)

Theory:

Block / Lec. No.	Topic	
Block-1	**Genetic diversity** Species and cultivar diversity: Floral and reproductive biology, cytogenetics, male sterility, incompatibility, wild and cultivated species, popular cultivars. Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm, IPR issues.	
Block-2	**Crop improvement** Breeding objectives: Breeding objectives/ goals on the basis of yield, quality, biotic and abiotic stress tolerance, adaptation. Breeding methods: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses. Screening for biotic and abiotic stresses; Bioinformatics in plantation and spice crops	
Block-3	**Breeding achievements and future thrusts** Breeding achievements: Breeding achievements in terms of released varieties, parentage, salient features. Future thrusts: Molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climate resilience	
Lecture No.	**Topic**	**Weightage**
	Genetic diversity, crop improvement, breeding achievements and future thrusts in	
1-3	Coconut	10
4-5	Arecanut	10
6-8	Cashew	10
9-11	Cocoa, Rubber, Oil palm	10
12-13	Coffee, Tea	10
14	Palmyrah, Betel vine,	10
15-17	Black pepper	10
18-19	Small and large cardamom	5
20-22	Nutmeg, Cinnamon, Clove, Allspice,	5
23-25	Ginger, Turmeric, *Kaempferia galangal* (Aromatic ginger), Garlic,	5
26-27	Garcinia, Tamarind	5
28-29	Fenugreek, Coriander	5
30-32	Fennel, Cumin, Ajwain, , etc.	5

Practical:

Practical's No.	Topic
1-2	Characterization and evaluation of germplasm of plantation and spice crops
3-4	Floral biology, anthesis; pollen behaviour, fruit set of plantation and spice crops
5-6	Practices in hybridization, selfing and crossing techniques of plantation and spice crops
7-8	Polyploidy breeding; Mutation breeding; Induction of somaclonal variation and screening the variants in plantation and spice crops
9-10	Evaluation of biometrical traits and quality traits of plantation and spice crops
11-15	Salient features of improved varieties and cultivars of plantation and spice crops
16	Exposure visits to research institutes for plantation and spice crops

Suggested reading:

Afoakwa EO. 2016. *Cocoa Production and Processing Technology*. CRC Press.
Anonymous. 1985. *Rubber and its Cultivation.* The Rubber Board of India.
Chadha KL, Ravindran PN and Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.
Chadha KL. 1998. *Advances in Horticulture*. Vol. IX,X. *Plantation and Spices Crops.* Malhotra Publishing House, New Delhi.
Chadha KL and Rethinam P. Eds. 1993. *Advances in Horticulture.* Vol. IX. *PlantationCropsand Spices.* Part-I. Malhotra Publ. House.
Chopra VL and Peter KV. 2002. *Handbook of Industrial Crops*. Haworth Press, USA and.Panama International Publ. (Indian Ed.).Choudappa P, Anitha K, Rajesh MK and Ramesh SV. 2017. *Biotechnology of Plantation Crops*.
Daya Publishing House,New Delhi.
Damodaran V K, Vilaschandran T and Valsalakumari PK. 1979. *Research on Cashew in India*.KAU, Trichur.
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
Harver AE. 1962. *Modern Coffee Production.* Leonard Hoff.
Kumar N. 2017. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*.CBS Publishers.
Nybe EV, MiniRaj N and Peter KV. 2007. *Spices.* New India Publishing Agency.
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.
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. *Spices.* Narendra Publishing House,New Delhi.
Raj PS and Vidyachandra B. 1981. *Review of Work Done on Cashew*. UAS Research Series No.6, Bangalore.
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 Ravindran PN. 2017. *The Encyclopedia of Herbs and Spices.* CABI

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.
Thampan PK. 1981. *Hand Book of Coconut Palm.* Oxford and IBH.

Course Title : Breeding of Medicinal and Aromatic Crops
Course Code : PSMA 505
Credit Hours : (2+1)

Theory:

Block / Lec. No.	Topic	
Block-1	**Genetic diversity** Species and cultivar diversity: Floral and reproductive biology, cytogenetics, male sterility, incompatibility, wild and cultivated species, popular cultivars. Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm, IPR issues.	
Block-2	**Crop improvement** 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. Breeding methods: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abioticstresses. *In-vitro* breeding in medicinal and aromatic crops.	
Block-3	**Breeding achievements and future thrusts** Breeding achievements: Breeding achievements in terms of released varieties, parentage, salient features. Future thrusts: Molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climate resilience.	
Lecture No.	**Topic**	**Weightage**
	Genetic diversity, crop improvement, breeding achievements and future thrusts in	
1-3	*Cassia angustifolia* (Senna), *Catharanthus roseus* (Periwinkle),	10
4-8	*Coleus forskohlii* (Coleus), *Stevia rebaudiana* (Candy leaf), *Withania somnifera* (Ashwgandha),	10
8-10	*Papaver somniferum* (Opium popy), *Plantago ovata* (Isabgol),	10
11-12	*Rauvolfia serpentine* (Sarpagandha), *Aloe vera*,	10
13-14	*Piper longum* (Indian long pepper), *Plumbago zeylanica* (Ceylon leadwort), etc	10
16-18	Mint, geranium,	10
19-20	patchouli, lemon grass, palmarosa,	15
21-22	citronella, vetiver,	5
23-24	Artemisia, ocimum,	5
25-27	lavender, *Kaempferia galangal* (Aromatic ginger),	5
28-29	Eucalyptus, Mitchellia, etc.	5
30-32	*Gloriosa superba* (Glory lily), *Chlorophytum* sp. (Spider ivy),	5

Practical:

Practical's No.	Topic
1-2	Description of botanical features of medicinal and aromatic crops
3-4	Cataloguing of cultivars, varieties and species in medicinal and aromatic crops
5-6	Floral biology of medicinal and aromatic crops
7-8	Selfing and crossing in medicinal and aromatic crops
9-10	Evaluation of hybrid progenies of medicinal and aromatic crops
11-14	Induction of economic mutants; High alkaloid and high essential oil mutants; Evolution of mutants through physical and chemical mutagens of medicinal and aromatic crops
15	Introduction of polyploidy in medicinal and aromatic crops
16	Screening for biotic and abiotic stress in medicinal and aromatic crops

Suggested reading:

Chadha KL and Gupta, R. 1995. *Advances in Horticulture.* Vol. XI. Malhotra Publ. House. Farooqi A A, Khan M M 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

Ponnuswami *et al.* 2018. *Medicinal Herbs and Herbal Cure*. Narendra Publishing House, New Delhi

Waghulkar VM. 2012. *Quality assurance techniques in pharmaceuticals.* New India Publishing Agency, New Delhi

Course Title : Systematics of Plantation and Spice Crops
Course Code : PSMA 506
Credit Hours : (1+1)

Theory:

Block / Lec. No.	**Topic**	
Block-1	**Origin and evolution** Centre of origin: Centre of origin, distribution, phylogeny Systematics: Botany, cytology, ploidy status, sex forms, flowering and pollination biology, cytogenetics.	
Block-2	**Diversity** Species and cultivar diversity: Wild and related species, cultivars Germplasm: Indigenous and exotic germplasm.	
Block-3	**Cataloguing** Descriptors: Biovarsity/ NBPGR descriptors and their salient features DUS guidelines: DUS guidelines, molecular aspects of systematic	
Lecture No.	**Topic**	**Weightage**
	Origin and evolution, Diversity and Cataloguing of	
1-3	Coconut,	10
4-8	Arecanut,	10
8-10	Cashew	10
11-12	Tea, Coffee	10
13-14	Oil Palm, , Cocoa	10
16-18	Rubber, Betel Vine	10
19-20	Black Pepper	15
21-22	Cardamom, Vanilla	5
23-24	Ginger, Turmeric, Garlic	5
25-27	Nutmeg, Cinnamon, Clove	5
28-29	Coriander, Fennel, Cumin, Fenugreek	5
30-32	Garcinia and indigenous species.	5

Practical:

Practical's No.	**Topic**
1-5	Genus, species and cultivar features of various plantation and spice crops;
5-7	Characterization based on descriptors of plantation and spice crops
8-10	Characterization of plantation and spice crops based on DUS guidelines
11-13	Study of sex forms and floral biology of plantation and spice crops
14-15	Study of molecular markers in plantation and spice crops
16	Exposure visits to national institutes including NBPGR

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

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

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 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

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

Course Title : Systematics of Medicinal and Aromatic Crops
Course Code : PSMA 507
Credit Hours : (1+1)

Theory:

Block / Lec. No.	Topic	
Block-1	**Origin and evolution** Centre of origin: Centre of origin, distribution, phylogeny, chemotaxonomy. Systematics: Botany, cytology, ploidy status, sex forms, flowering and pollination biology, cytogenetics.	
Block-2	**Diversity** Species and cultivar diversity: Wild and related species, cultivars Germplasm: Indigenous and exotic germplasm.	
Block-3	**Cataloguing** Descriptors: Biovarsity/ NBPGR descriptors and their salient features DUS guidelines: DUS guidelines, molecular aspects of systematics	
Lecture No.	**Topic**	**Weightage**
	Origin and evolution, Diversity and Cataloguing of	
1-3	Opium poppy, Isabgol,	10
3-5	Senna, , Glory Lily	10
6-8	Aswagandha , Medicinal coleus	10
8-11	Periwinkle, Sarpagandha, Long Pepper	10
12-15	Stevia, Safed musli, *Plumbago zeylanica* (Ceylone leadwort)	10
16-19	Medicinal solanum, Alov vera, etc.	10
20-21	Lemongrass, Citronella	10
22-23	Palmarosa, Vetiver	10
24-25	Mint, Patcholi, Geranium	5
26-27	Ocimum, Rosemary	5
28-29	Lavender, *Kaempferia galangal*	5
30-32	Eucalyptus, Mitchellia, *Jasminum sp.*, etc.	5

Practical:

Practical's No.	Topic
1-5	Genus, species and cultivar features of various medicinal and aromatic crops
5-7	Characterization based on descriptors of medicinal and aromatic crops
8-10	Characterization of medicinal and aromatic crops based on DUS guidelines
11-13	Study of sex forms and floral biology of medicinal and aromatic crops
14-15	Study of molecular markers in medicinal and aromatic crops
16	Exposure visits to national institutes.

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.

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

Prajapati ND, Purohit SS, Sharma AK, Kumar T. 2006. *A Hand book of Medicinal Plants.* Agro Bios (India).

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 Raju R Wadekar. 2015. *Pharmacognosy and phytochemistry*, Event publishing house

Ranjal Kandall. *Bioactive compounds and genomic study of medicinal plants*. LAMBERT Academic Publishing

Sharma G. 2009. *Systematics of fruit Crops*. New India Publishing House, India. 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.

Course Title : Underexploited Plantation, Spice, Medicinal and Aromatic Plants
Course Code : PSMA 508
Credit Hours : (2+0)

Theory:

Block / Lec. No.	**Topic**	
Block-1	**Importance and status** Importance and Uses: Introduction, importance, economic parts used, traditional uses. Status and future prospects: Present status, origin, distribution and future prospects of under exploited PSMAs.	
Block-2	**Production technology** Propagation and varieties: Propagation and nursery techniques, species varieties. Agro techniques: Climatic and soil requirements, planting and aftercare, weed and water management, manuring, plant protection.	
Block-3	**Harvest and post harvest management** Harvest indices: Maturity indices, harvesting time, techniques, crop duration. Post harvest management: Primary processing, extraction and value addition, packaging, storage, marketing, active ingredients.	
Lecture No.	Topic	**Weightage**
	Importance and status. Production technology, harvest and post harvest management of	
1-3	Wattle, minor species of Areca and wild palms	10
3-5	Coffea, Hevea	10
6-8	*Illicium verum, Myristica malabarica, M. beddomei*	10
8-11	*Cinnamomum tamala, C. malabatrum, Xanthoxylum* sp. *Curcuma caesia, C. aromatica, C. zedoaria, C. amada,*	10
12-15	*Anethum graveolense, Hyssopus officinalis*	10
16-19	*Eringiumfoetidum, Pimpinella anisum, Artocarpus lacucha.*	10
20-21	*Flacourtia montana, Plectranthus aromaticus, Adhatoda* sp. *Hemidesmus indicus*	10
22-23	*Tinospora cordifolia, Gymnema sylvestre, Psoralea corylifolia, Eclipta alba, Aristalochia indica, Morinda citrifolia,*	10
24-25	*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,*	5

26-27	*Nardostachis jatamansi,Valeriana officinalis, Swertia chiraita, Aconitum* sp., *Salvia officinalis, Centella asiatica, Bixa orellana, Bacopa monnieri*	5
28-29	*Bursera* sp., *Commiphora wightii, Ocimum kilimandjaricum, Melaleuca, Michaelia champaka*,	5
30-32	*Rosa damascena, Cananga odorata,* marjoram, chamomile	5

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 AromaticPlants.*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.

Course Title : Growth and Development of Plantation, Spice, Medicinal and Aromatic Crops
Course Code : PSMA 509
Credit Hours : (2+1)

Theory:

Block / Lec. No.	Topic
Block-1	**Growth, development, assimilate partitioning and plant bio regulators** Stages of growth: Growth and development, definitions, components, photosynthetic productivity, different stages of growth, growth curves, growth analysis, morphogenesis in PSMAs. Growth pattern: in annual, semi-perennial and perennial crops, growth dimorphism, environmental impact on growth and development: effect of light, temperature, photoperiod. Assimilate partitioning: Assimilate partitioning during growth and development, influence of water and mineral nutrition.
Block-2	**Canopy management** Canopy management for conventional and high density planting pruning, training, chemicals, crop regulation for year round and off season production in PSMAs. Plant bio regulators: plant bio regulators auxins, gibberellins, cytokinins, ethylene, inhibitors and retardants, basic functions, biosynthesis and role in crop growth and development.
Block-3	**Developmental physiology and biochemistry** Vegetative phase: Developmental physiology and biochemistry during dormancy, bud break, juvenility. 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. Growth and development process during stress: Growth and development process during stress, production of secondary metabolites, molecular and genetic approaches in growth and development.

Lecture No.	Topic	Weightage
1-5	Stages of growth: Growth and development, definitions, components, photosynthetic productivity, different stages of growth, growth curves, growth analysis, morphogenesis in PSMAs.	15
6-8	Growth pattern: in annual, semi-perennial and perennial crops, growth dimorphism, environmental impact on growth and development:	15
9-13	effectof light, temperature, photoperiod. Assimilate partitioning: Assimilate partitioning during growth and development, influence of water and mineral nutrition.	15
14-17	Canopy management for conventional and high density planting pruning, training, chemicals, crop regulation for year round and off season production in PSMAs.	10

18-21	Plant bio regulators: plant bio regulators auXins, gibberellins, cytokinins, ethylene, inhibitors and retardants, basic functions,biosynthesis and role in crop growth and development.	10
22-25	Developmental physiology and biochemistry during dormancy, bud break, juvenility.	10
25-28	Physiology of flowering, photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism, pollination, fertilisation, fruit set, fruit drop, fruit growth, ripening, seed development in PSMAs.	10
29-30	Growth and development process during stress,	5
31-32	Production of secondary metabolites, molecular and genetic approaches in growth and development.	10

Practical:

Practical's No.	Topic
1-3	Dormancy mechanisms in seeds, seed rhizomes of PSMA crops
4-6	Techniques of growth analysis in PSMA crops.
7-9	Evaluation of photosynthetic efficiency under different environments in PSMA crops.
10-12	Technologies for crop regulation in cashew, coffee, cocoa, etc.
13-14	Root shoot studies, flower thinning, fruit thinning in PSMA crops.
15	Crop regulation for year round production in PSMA crops.
16	Use of growth regulators in PSMA crops.

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.

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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.

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Course Title : Biochemistry of Plantation, Spices, Medicinal and Aromatic Crops
Course Code : PSMA 510
Credit Hours : (2+1)

Theory:

Block / Lec. No.	**Topic**
Block-1	**Post-harvest physiology** 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. Contaminants: Adulterants, and substitutes, sources of contamination- microbial, heavy metal, pesticide residues in PSMAs
Block-2	**Value addition** 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, flavor perfumery and pharmaceutical industries. Quality standards: Quality standards of raw materials and finished products.
Block-3	**Extraction techniques :** Extraction methods: Basic and advanced extraction techniques in PSMAs-Soxhlet, SCFE, Membrane extraction. Chemical characterization-HPTLC, GCMS, LCMS, NMR. 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. *In-vitro* production of secondary metabolites in PSMA crops.

Lect.No.	**Topic**	**Weightage**
1-5	Maturity indices, changes during ripening, processing, factors affecting quality.	15
6-8	Secondary metabolites and their biosynthetic pathways, factors affecting production of secondary metabolites.	10
9-13	Contaminants: Adulterants, and substitutes, sources of contamination- microbial, heavy metal, pesticide residues in PSMAs	10
14-17	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, flavor perfumery and pharmaceutical industries.	15
18-20	Medicinal and pharmacological properties, use in the food, flavor perfumery and pharmaceutical industries.	10
21-23	Quality standards: Quality standards of raw materials and finished products.	10
24-26	Basic and advanced extraction techniques in PSMAs-Soxhlet, SCFE, Membrane extraction.	10

27-29	Plant tissue culture: Plant tissue cultures in the industrial production of bioactive plant metabolites.	10
30-32	Cell suspension culture systems for large scale culturing of plant cells and production of secondary metabolites. Advantages of cell culture over conventional extraction techniques.	10

Practical:

Practical's No.	Topic
1-2	Biochemical characterization of PSMA crops.
3-4	Detection of adulterants and substitutes in of PSMA crops.
4-6	Extraction and quantification of secondary metabolites of PSMA crops.
7-9	Chromatographic separation of the products of PSMA crops.
10-11	Testing the product of PSMA crops.
12-13	Exposure visit to leading industries of PSMA crops.
14-16	Assessment of antimicrobial properties in PSMA crops.

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.

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Hammon JM and Yusibov V. 2000. *Plant Biotechnology*: New Products and application. Springer- Verlag.

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Ranjal Kandall. *Bioactive compounds and genomic study of medicinal plants*. LAMBERT Academic Publishing.

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Shankar SJ. 2018. Comprehensive post harvest technology of flowers, medicinal and aromaticplants. Narendra Publishing House, New Delhi

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Tiwari C. 2018. *Antimicrobial properties of Medicinal plants*. Narendra Publishing House, New Delhi.

Trivedi C. 2004. *Herbal drugs and biotechnology*. Pointer Publishers.

Waghulkar VM. 2012. *Quality assurance techniques in pharmaceuticals*. New India Publishing Agency, New Delhi.

Course Title : Biodiversity and Conservation of Plantation, SpicesMedicinal and Aromatic Crops
Course Code : PSMA 511
Credit Hours : (2+1)

Theory:

Block / Lec. No.	Topic
Block-1	**Plantation and Spice crops** Biodiversity: Biodiversity, issues and goals, centres of origin of Plantation and spice crops, primary and secondary centres of genetic diversity. 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. 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. 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-2	**Medicinal and aromatic crops** Biodiversity: Biodiversity, issues and goals, centres of origin of Plantation and spice crops, primary and secondary centres of genetic diversity. 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 medicinal and aromatic crops, gene bank management. 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. National and international issues: Genetic resources management of Medicinal and aromatic 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.

Lecture No.	Topic	Weightage
1-4	Biodiversity: Biodiversity, issues and goals, centres of origin of Plantation and spice crops, primary and secondary centres of genetic diversity of PSMA's	10
5-7	Germplasm collection and quarantine: Exploration and germplasm collection, planning and logistics, exchange of germplasm, plant quarantine principles, regulations plant quarantine systems in India for PSMA's	10
8-10	Components of germplasm evaluation, descriptor lists. Conservation of genetics resources, Concept of base and active collections, long and short term storage of PSMA crops,	10
11-12	Gene bank management Documentation and cataloguing in PSMA's	10
13-15	Recent approaches and role of biotechnology in PGR conservation documentation and data base management, cataloguing gene bank information in PSMA's. Detection of adulterants and substitutes in PSMAs	10
16-17	Molecular markers in characterization of plant genetic resources of PSMA's	10
18-19	GIS in biodiversity mapping of PSMA's	10
20-24	National and international issues: Genetic resources management of PSMA's in India and in International perspective.	10
25-28	Bio diversity concerns, national and international regulations, conservation networks in PSMA's	10
29-32	Good collection practices, domestication, PPV and FRA and DUS testing. Geographical indication, Biodiversity act and biodiversity legislations.	10

Practical:

Practical's No.	Topic
1-3	Collection and identification of different plantation, spice, medicinal and aromatic plants from natural sources
3-4	Preparation of herbarium of PSMA's
4-5	Botanical and phyto-chemical grouping of PSMAs.
6-7	Classification of PSMAs based on plant parts used
8-9	Documentation of germplasm of PSMA's
9-10	Maintenance of passport data and other records of PSMA's
11	Field explorations of PSMA's
12-13	Ethno botanical studies of PSMA's in tribal areas
14-15	Planning and layout of herbal gardens of PSMA's
16	Exposure visits to herbaria, herbal gardens and important organizations engaged in collection and utilization of PSMAs.

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.

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Kassahun Beemnet, Jemal Omar Sherif, Tessema sion, Abate Solomon. 2009. *Production, Processing and utilization of Aromatic Plants.* EIAR.

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Sethuraj MR and Mathew NT. 1992. *Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science)*. Elsevier Science.

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Trivedi PC. *Medicinal Plants: Utilization and Conservation.*

11. SEMESTER WISE LAYOUT FOR Ph.D. (Hort)
PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

I SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
PSMA 601*	Advances in Production of Plantation and Spice Crops	3+0
PSMA 602*	Advances in Production of Medicinal and Aromatic Crops	3+0
PSMA 606	Abiotic Stress Management in Plantation, Spice, Medicinal	2+1
PSMA 699	Research	0+1
	Total (A)	**8+2=10**
	B) Minor courses	
FSC 602	Modern Trends in Fruit Production	3+0
	Total (B)	**3**
	C) Supporting Courses	
VSC 601	Recent Trends in Vegetable Production	3+0
	Total (C)	**3**
	Total (A+B+C)	**16**
	D) Non Credit Courses	
PGS 501	Library and Information Services	0+1
PGS 504	Basic Concept of Laboratory Techniques	0+1
	Total (D)	**2**
	Total (A+B+C+D)	**18**

***Compulsory course**

II SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
PSMA 603*	Recent Breeding Approaches in Plantation, Spice,	3+0
PSMA 607	Organic Spice and Plantation Crops Production	2+1
PSMA -699	Research	0+5
	Total (A)	**5+6=11**
	B) Minor courses	
PP 607	Physiological and Molecular Aspects of Source-sink Capacity for Enhancing Yield	3+0
FLS 602	Postharvest Biology of Floricultural Crops	2+1
	Total (B)	**3**

	C) Supporting Courses	
FLS 605	Advances in Landscaping	1+1
	Total (C)	**2**
	Total (A+B+C)	**16**
	D) Non Credit Courses	
PGS 502	Technical Writing and Communication Skill	0+1
PGS 503	Intellectual Property and its Management in Agriculture	1+0
	Total (D)	**2**
	Total (A+B+C+D)	**18**

***Compulsory course**

Note: One course should be selected from minor courses.

III SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
PSMA 691	Seminar-I	0+1
PSMA - 699	Research	0+16
	Total (A)	**0+17=17**
	B) Minor courses	**NIL**
	C) Supporting Courses	**NIL**
	D) Non Credit Courses	
PGS 505	Agricultural Research, Research Ethics and Rural Development Programme	1+0
	Total (D)	**1**
	Total (A+B+C+D)	**18**

IV SEMESTER

CourseNo	Course Title	Credit Hours
	A) Major courses	
PSMA 692	Seminar II	0+1
PSMA -699	Research	0+17
	Total	**18**

V SEMESTER

CourseNo	Course Title	Credit Hours
	A) Major courses	
PSMA -699	Research	0+18
	Total	**18**

VI SEMESTER

Course No	Course Title	Credit Hours
	A) Major courses	
PSMA -699	Research	0+18
	Total	**18**

12. Ph.D. PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS Course Structure and Course Contents

Course title with Credit load Ph.D. (Hort.) in PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

Course Code	Course Title	Credit Hours
	Major Courses (12 Credits)	
PSMA 601*	Advances in Production of Plantation and Spice Crops	3+0
PSMA 602*	Advances in Production of Medicinal and Aromatic Crops	3+0
PSMA 603*	Recent Breeding Approaches in Plantation, Spice,	3+0
PSMA 604	Advanced Methods in Laboratory Techniques	1+2
PSMA 605	Biotechnological Approaches in PSMA Crops	3+0
PSMA 606	Abiotic Stress Management in Plantation, Spice, Medicinal	2+1
PSMA 607	Organic Spice and Plantation Crops Production	2+1
PSMA 608	Marketing and Export of Plantation, Spice, Medicinal	2+1
	Minor courses	06
	Supporting courses	05
PSMA 691	Seminar-I	0+1
PSMA 692	Seminar-II	0+1
PSMA 699	Research	0+75
	Total	**100**

Course Title : Advances in Production of Plantation and Spice Crops

Course Code : PSMA 601

Credit Hours : (3+0)

Theory:

Block / Lec. No.	Topic	
Block-1	**Importance of Plantation and Spice Crops** Area, production, productivity: Indian and world scenario: Role of plantation and spice crops in national economy, area-production statistics at national and international level, productivity challenges, industrial requirement of plantation and spice crops, demand-supply scenario of plantation and spice crop. Export potential: Export scenario, market opportunities and challenges in plantation and spice crops, global imports and exports, export of organic produce and products. Promotional programmes: Role of commodity boards and directorates in the development programmes of plantation and spice crops, contract farming, Farmer Producer Organizations (FPO) and Farmer Producer Companies (FPC).	
Block-2	**Advanced Agrotechniques** Varietal wealth and planting material production: Cultivars and improved varieties in plantation and spice crops, mass multiplication techniques, hi-tech nursery techniques. Agrotechniques: Precision farming techniques, HDP systems, fertigation, chemical regulation of crop productivity, protected cultivation of high value crops, mechanization in plantation and spice crops, hydroponics, aeroponics, application of nanotechnology, robotics. Impact of climate change: Impact of biotic and abiotic factors on growth and productivity, climate resilient technologies in plantation and spice crops, soil health management, organic production systems.	
Block-3	**Harvest and postharvest management** Maturity indices and harvest: Influence of pre and post harvest factors on quality of plantation and spice crops, pre and post harvest management techniques for improving quality, good manufacturing practices in plantation and spice sector. Quality standards: Domestic and international standards, HACCP, BIS standards, domestic and export grades, modern packaging techniques, export protocols.	
	Importance, Advanced Agrotechniques, Harvest and postharvest management of	
1-4	Coconut	10
5-8	Arecanut	10
8-11	Cashew	10
12-15	Coffee ,Tea	5
16-19	Cocoa, Rubber	5
19-21	Oil palm, Palmyrah	5
22-24	Bettle vine, Wattle	5
25-27	Black pepper	10
28-31	Cardamom, Cinnamon	10
32-34	Turmeric	10

35-37	Ginger	5
38-40	Nutmeg , Clove	5
41-43	Garcinia, Vanilla	5
44-46	Coriander, Cumin, Fennel	10
47-48	Fenugreek, Ajwain, Dill, Safron, etc.	5

Suggested Reading

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

Agarwal S, Divkarasastry EV and Sharma RK. 2001. *Seed Spices, Production, Quality and Export*. Pointer Publ.

Anonymous. 1985. *Rubber and its Cultivation.* The Rubber Board of India.

Barche S. 2016. *Production Technology o Spices, Aromatic, Medicinal and Plantation Crops*.New India Publishing Agency, New Delhi.

Chadha KL. 2001. *Hand Book of Horticulture*. ICAR.

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Nair MK, Bhaskararao EVV, Nambiar KKN and Nambiar MC. 1979. *Cashew*.

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Purseglove JW, Brown EG, Green CL and Robbins SRJ. 1984. *Spices*. Vols. I, II. Longman.

Purseglove JW. 1968. *Tropical Crops–Dicotyledons*. Longman.

Ramachandra *et al*. 2018. *Breeding of Spices and Plantation crops*. Narendra Publishing House, New Delhi.

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Sharangi AB and Acharya SK. 2008. *Quality management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2

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Swain SC. 2018. *Precision Farming in Horticulture: Approaches and strategies*. Narendra Publishing House, New Delhi.

Thampan PK. 1981. *Hand Book of Coconut Palm*. Oxford and IBH.

Varmudy V. 2001. *Marketing of Spices*. Daya Publ. House.

Winton AL and Winton KB. 1931. *The Structure and Composition of Food*. John Wiley and Sons.

Yagna Narayan Ayer AK. 1960. *Cultivation of Cloves in India*. ICAR.

Course Title : Advances in Production of Medicinal and Aromatic Crops
Code : PSMA 602
Credit Hours : (3+0)

Theory:

Block / Lec. No.	Topic
Block-1	**Importance of Medicinal and Aromatic Crops** Biodiversity of medicinal and aromatic crops (MAPs): Biodiversity of MAPs, conservation networks, global initiatives on medicinal plants conservation and development, World history on usage of MAPs, preference to natural products. Indian traditional wisdom and heritage, Indian herbal wealth, documentations, databases, scientific validation. Area, production and productivity statistics: Role of medicinal and aromatic crops in national economy, area-production statistics at national and international level, productivity challenges, Trends in food, flavouring, perfumery and cosmetic industries, requirement in the ayurvedic, pharmaceutical, perfume and cosmetic industries, demand-supply scenario of MAPs. Export potential: Export and import of crude drugs, standardized extracts, aromatic plants, essential oils. Intellectual Property Rights, patents. Contract farming. Role of Medicinal Plant Board in promotional programmes of MAPs.
Block-2	**Advanced Agrotechniques** Domestication of medicinal and aromatic crops: Need for domestication, changes on domestication, influence of environment on secondary metabolite production, developing cultivation packages for emerging crops. Varietal wealth and planting material production: Cultivars and improved varieties in medicinal and aromatic crops, mass multiplication techniques, micropropagation, hi-tech nursery techniques. Agro techniques: Advanced research in the field of growth and development, nutrition and irrigation requirements, inter culture, mulching, weed control. Precision farming techniques, HDP systems, fertigation, chemical regulation of crop productivity, protected cultivation of high value crops, hydroponics, aeroponics, application of nanotechnology, nano- fertilizers, nano-pesticides, robotics. Impact of climate change: Impact of biotic and abiotic factors on growth, productivity and quality, climate resilient technologies in medicinal and aromatic crops, soil health management, organic production systems.
Block-3	**Harvest and postharvest management** Maturity indices and harvest: Influence of pre and post harvest factors on quality of medicinal and aromatic crops, pre and post harvest management techniques for improving quality, good manufacturing practices in herbal sector. Modern methods of extraction of MAPs: Advanced essential oil extraction and value addition methods in aromatic plants, advances in phytochemical extraction technologies, separation of bio-molecules, phytochemicals and drug development. Pharmacology and pharmacognosy, *in vivo* and *in-vitro* extraction of secondary metabolites, bioreactors. Quality standards: Quality standards in medicinal and aromatic plants, quality standards in crude drugs and finished products, use of aroma chemicals, aroma therapy, advanced research in biomedicines, nutraceuticals and natural drugs, American,

	European and Asian legislations on plant drugs, domestic and international standards, modern packaging techniques.	
Importance, Advanced Agro-techniques, Harvest and postharvest management of		
1-4	Coleus, Glory lily, Senna	10
5-8	Periwinkle, Stevia, Aswagandha	10
8-11	Sarpagandha, Aloe, *Phyllanthus amarus* (Bhui awala)	10
12-15	*Andrographis paniculata* (Kalmegh), Isabgol, Poppy, *Digitalis* sp. (Lady's glove)	10
16-19	*Commiphora* sp., Ipecac, Henbane,	10
19-21	Oil palm, Palmyrah	10
22-24	Bettle vine, Wattle	10
25-27	*Ocimum* sp. (Tulsi), Centella, Bacopa (Brahmi)	10
28-31	Saraca (Ashok tree), Valerian, Jatamansi (Guggul)	10
32-34	Aconite, Ephedra and Bael	10
35-37	Palmarosa, Lemongrass, Citronella,	10
38-40	Vetiver, Geranium, Mint,	10
41-43	Eucalyptus, Rosemary, Artemisia	10
44-46	Thyme, Patchouli, Rose	10
47-48	Jasmine, Lavender, etc.	10

Suggested Reading

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Course Title : Recent Breeding Approaches in Plantation, Spice, Medicinal and Aromatic Crops
Course Code : PSMA 603
Credit Hours : (3+0)

Theory:

Block / Lec. No.	Topic	
Block-1	**Plantation Crops** Genetic resources: Evolutionary mechanisms, adaptation and domestication, genetic resources, genetic divergence, cytogenetics, variations and natural selection, types of pollination and fertilization mechanisms, sterility and incompatibility systems in Plantation crops. Breeding methods: Introduction and selection, chimeras, clonal selections, intergeneric, interspecific and inter-varietal hybridization, heterosis breeding, mutation and polyploidy breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, genetics of important traits and their inheritance pattern, molecular and transgenic approaches and other biotechnological tools in crop improvement. Breeding achievements: Breeding objectives, ideotype breeding, breeding problems and achievements in Plantation crops.	
Block-2	**Spice crops** Genetic resources: Evolutionary mechanisms, adaptation and domestication, genetic resources, genetic divergence, cytogenetics, variations and natural selection, types of pollination and fertilization mechanisms, sterility and incompatibility systems in Spice crops. Breeding methods: Introduction and selection, chimeras, clonal selections, intergeneric, interspecific and intervarietal hybridization, heterosis breeding, mutation and polyploidy breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, genetics of important traits and their inheritance pattern, molecular and transgenic approaches and other biotechnological tools in crop improvement. Breeding achievements: Breeding objectives, ideotype breeding, breeding problems and achievements in Spice crops.	
Block-3	**Medicinal and aromatic crops** Genetic resources: Evolutionary mechanisms, adaptation and domestication, genetic resources, genetic divergence, cytogenetics, variations and natural selection, chemotaXonomy, pollination and fertilization mechanisms, sterility and incompatibility systems in Medicinal and Aromatic crops. Breeding methods: Introduction and selection, clonal selections, intergeneric, interspecific and intervarietal hybridization, heterosis breeding, mutation and polyploidy breeding, resistance breeding to biotic and abiotic stresses, breeding for improving quality, genetics of important traits and their inheritance pattern, genetic mechanisms associated with secondary metabolites, molecular and transgenic approaches and other biotechnological tools in crop improvement. Breeding achievements: Specific breeding objectives in medicinal and aromatic crops, ideotype breeding, breeding problems and achievements in medicinal and aromatic crops.	
	Genetic resources, Breeding methods and Breeding achievements of	
1-4	Coconut, Arecanut,	10
5-8	Coffee, Tea	10
8-11	Cashew, , Rubber	10

12-15	Oil palm Cocoa	10
16-19	Black pepper, Cardamom	10
19-21	Ginger, Turmeric	10
22-24	Nutmeg, Cinnamon,Clove	10
25-27	Garcinia,	10
28-31	Coriander, Cumin, Fennel	10
32-34	Fenugreek, Ajwain, Dill	10
35-37	Sarpagandha, Ocimum, *Aloe vera*, Poppy	10
38-40	Senna, Periwinkle, Aswagandha, Isabgol,	10
41-43	Glory lily, Medicinal coleus, *Mucuna pruriens*, , *Centella asiatica*, *Bacopa monnieri*, *Andrographis paniculata*, , *Phyllanthus amarus*, Eucalyptus, Bael, Henbane.	10
44-46	Lemongrass, Palmarosa, Citronella, Vetiver, Mint Lavender, Geranium	10
47-48	Artemisia, Rosemary, Thyme, Sage, Marjoram, Fever few. Sweet basil, , Patchouli,	10

Suggested Reading

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Agarwal S, Divkarasastry EV and Sharma RK. 2001. *Seed Spices, Production, Quality and Export*. Pointer Publ.

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Sethuraj MR and Mathew NT. 1992. *Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science)*. Elsevier Science.
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Srivastava HC, Vatsaya and Menon KKG. 1986. *Plantation Crops–Opportunities and Constraints*. Oxford and IBH.
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Course Title : Advances in Laboratory Techniques for PSMA Crops
Course Code : PSMA 604
Credit Hours : (1+2)

Theory:

Block / Lec. No.	Topic	
Block-1	**Plantation Crops** Physiological and biochemical changes: Physiological and biochemical changes during maturity and ripening including post harvest changes. Factors influencing quality. Contaminants: Adulterants, substitutes, sources of contamination: microbial, heavy metal, pesticide residues. Value addition: Fixed oils,value added products, grading, storage, transportation.	
Block-2	**Spice crops** Physiological and biochemical changes: Physiological and biochemical changes during maturity and ripening including post harvest changes. Factors influencing quality. Contaminants: Adulterants, substitutes, sources of contamination: microbial, heavy metal, pesticide residues. Value addition: Fixed oils, value added products, grading, storage, transportation.	
Block-3	**Medicinal and aromatic crops** Secondary metabolites and their biosynthetic pathways, factors affecting production of secondary metaboiltes, changes during maturity, harvesting and processing. Contaminants: Adulterants, substitutes, contamination: microbial, heavy metal, pesticide residues. Value addition: Fixed oils, essential oils, oleoresins, concretes, absolutes, dyes, natural colours, aroma chemicals, grading, storage, transportation. Quality standards of raw materials and finishedproducts.	
1-2	Physiological and biochemical changes: Physiological and biochemical changes during maturity and ripening including post harvest changes in plantation crops	4
3	Factors influencing quality of plantation crops	4
4-5	Contaminants: Adulterants, substitutes, sources of contamination: microbial, heavy metal, pesticide residues in plantation crops	4
6	Fixed oils, essential oils, oleoresins, concretes, absolutes,dyes, natural colours, aroma chemicals, grading, storage, transportation of plantation crops	4
7	Physiological and biochemical changes: Physiological and biochemical changes during maturity and ripening including post harvest changes in spice crops	4
8	Factors influencing quality of spice crops	4
9	Contaminants: Adulterants, substitutes, sources of contamination: microbial, heavy metal, pesticide residues in spice crops	4
10-11	Fixed oils, essential oils, oleoresins, concretes, absolutes,dyes, natural colours, aroma chemicals, grading, storage, transportation of spice crops	5
12-13	Secondary metabolites and their biosynthetic pathways, factors affecting production of secondary metaboiltes, changes during maturity,harvesting and processing of medicinal and aromatic crops.	4

14	Contaminants: Adulterants, substitutes, contamination: microbial, heavy metal, pesticide residues in medicinal and aromatic crops.	4
15	Value addition: Fixed oils, essential oils, oleoresins, concretes, absolutes, dyes, natural colours, aroma chemicals, grading, storage, transportation of medicinal and aromatic crops.	4
16	Quality standards of raw materials and finished products of plantation, spices, medicinal and aromatic crops	5

Practical:

Practicals No.	Topic
1	Sampling techniques in PSMA crops or their parts
2	Detection of adulterants and substitutes
3	Extraction of secondary metabolites from medicinal crops
4	Qualitative analyses of secondary metabolites
5	Quantitative estimation of secondary metabolites
6	Preparation of plant extracts
7	Chromatographic separation of extracts
8	Thin layer chromatography
9	Soxhlet extraction
10	Super critical fluid extraction
11-12	Determination of physical and chemical properties of essential oils
13	Flavor profile of essential oils by gas chromatography
14	Chemical characterization by HPTLC
15	Chemical characterization by GCMS
16	Chemical characterization by LCMS
17	Chemical characterization by NMR
18-19	Bioassay and High Throughput Screening
20-21	Techniques for assessment of antimicrobial property
22-25	Techniques for assessment of antioxidant property, pesticide residue analyses
26-28	Determination of heavy metals by flame photometry
29-30	Plant tissue cultures in the industrial production of bioactive plant metabolites
31-32	Exposure visit to leading medicinal and aromatic industries, accredited quality control labs

Suggested Reading

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. Hammon JM and Yusibov V. 2000. *Plant Biotechnology: New Products and application*. Springer-Verlag.

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Tiwari C. 2018. *Antimicrobial properties of Medicinal plants*. Narendra Publishing House, New Delhi.

Trivedi C. 2004. *Herbal drugs and biotechnology*. Pointer Publishers.

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Course Title : Biotechnological Approaches in Plantation, Spice, Medicinal and Aromatic Crops
Course Code : PSMA 605
Credit Hours : (3+0)

Theory:

Block / Lec. No.	Topic
Block-1	**Plantation Crops** *In-vitro* mass multiplication techniques: *In-vitro* conservation of plantation crops, direct and indirect organogenesis, micro grafting, hardening techniques. *In-vitro* breeding: Production of haploids, somaclones and identification of somaclonal variants, *in-vitro* techniques to overcome fertilization barriers, protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species. *In-vitro* mutation for biotic and abiotic stresses, disease elimination in crops. Transgenic crops: Recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology. Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars, etc., achievements, problems and future thrusts.
Block-2	**Spice crops** *In-vitro* mass multiplication techniques: *In-vitro* conservation of spice crops. direct and indirect organogenesis, micro grafting, hardening techniques, production of microrhizomes. *In-vitro* breeding: Production of haploids, somaclones and identification of somaclonal variants, *in-vitro* techniques to overcome fertilization barriers, Protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in-vitro* mutation for biotic and abiotic stresses, disease elimination in crops. Transgeni Recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology. Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars, etc., achievements, problems and futurethrusts.
Block-3	**Medicinal and aromatic crops** *In-vitro* mass multiplication techniques: *In-vitro* conservation of medicinal and aromatic crops, direct and indirect organogenesis, micro grafting, hardening techniques, production of microrhizomes. *In-vitro* breeding: Production of haploids, somaclones and identification of somaclonal variants, *in-vitro* techniques to overcome fertilization barriers, Protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species, *in-vitro* mutation for biotic and abiotic stresses, disease elimination in crops. Transgenic crops: Recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology. Role of molecular markers in

	characterization of transgenic crops, finger printing of cultivars, etc., achievements, problems and future thrusts. *In-vitro* production of secondary metabolites: *In-vitro* production and characterization of secondary metabolites, bioreactors.	
	Biotechnological Approaches in	
1-3	Coconut	10
4-6	Rubber	10
7-8	Oil palm	5
9-10	Coffee	5
11-12	Tea	10
13-14	Cocoa	5
15-17	Black pepper	10
18-19	Cardamom	10
20-21	Turmeric	10
22-23	Ginger	5
24-25	Vanilla	10
26-28	Periwinkle	10
29-30	Rauvolfia	5
31-32	Mint	10
33-34	Cymbopogon grasses	5
35-36	Medicinal coleus	5
37-39	*Ocimum* sp	5
40-42	Aswagandha	5
43-44	Aloe	5
45-46	Safed musli	5
47-48	Stevia	5

Suggested Reading

Afoakwa EO. 2016. *Cocoa Production and Processing Technology*. CRC Press. Bajaj YPS. Ed. 1987. *Biotechnology in Agriculture and Forestry*. Springer.

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Course Title : Abiotic Stress Management in Plantation, Spices, Medicinal and Aromatic Crops
Course Code : PSMA 606
Credit Hours (2+1)

Theory:

Block / Lec. No.	Topic	
Block-1	**Abiotic Stress**	
1-5	Temperature and water stress: Stresses due to water (high and low), temperature (high and low), symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality.	**10**
6-9	Stress due to soil conditions and salts: Alkainity, salinity, iron toxicity, fertilizer toxicity symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality.	**10**
10-13	Pollution stress: Gaseous pollutants and heavy metals, symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality.	**10**
14-16	Other stresses: Stress due to radiation, wind, nutrients. symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality.	**10**
Block-2	**Climate change**	
17-19	Contributing factors: Introduction to climate change, factors contributing to climate change, change in temperature, rainfall, humidity, rise in the atmospheric CO_2 levels, tropospheric ozone levels,extreme climatic events.	**10**
20-22	Carbon trading: Global warming, carbon trading, role of green housegases, impact on productivity of PSMA crops. Clean development mechanism.	**10**
23-25	Impact of climate change on PSMA crops: Plantation crops, Spice crops, Medicinal and aromatic crops.	**10**
Block-3	**Climate resilient technologies**	
26-27	Varieties: Plantation crops, Spice crops, Medicinal and aromatic crops.	**10**
28-30	Climate resilient technologies: Plantation crops, Spice crops, Medicinal and aromatic crops.	10
31-32	Waste management: Alternate farming systems, Zero waste management, Microbial waste management in PSMA's	10

Practical:

Practicals No.	Topic
1	Analysis of plant stress factors in PSMAs
2	Relative water content in PSMAs
3	Chlorophyll stability index OF PSMAs
4	Plant waxes in PSMAs
5	Stomatal diffusive resistance of PSMAs
6	Transpiration in PSMAs
7	Photosynthetic rates in PSMAs
8	Calculation of water use efficiency and growth rates of PSMAs
9	Identifying abiotic stress symptoms and injuries in PSMAs
10	Use of antitranspirants in PSMAs
11	Managing nutrient stress in PSMAs
12	Stress management by hormones in PSMAs
13	Screening for abiotic stress tolerance in PSMAs
14	Weather data analyses and quantification of climate change in PSMAs
15	Cropping pattern changes due to climate extremities of PSMAs
16	Phenological and quality changes, Pesticide residue analysis in PSMAs;

Suggested Reading

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Venkateswarlu B, Shanker AK, Chitra M and Maheswari M. *Crop Stress and its Management: Perspectives and Strategies*. Springer.

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Course Title : Organic Spice and Plantation Crops Production

Course Code : PSMA 607

Credit Hours : (2+1)

Theory:

Block / Lec. No.	Topic	Weightage
Block-1	**Concepts of Organic Farming in PSMA's**	
1-3	Importance: Principles, perspectives, concepts and components of organic farming, present status of organic farming at national and global level, domestic and global demand for organic products with respect to spice and plantation crops, organic production and export– opportunities and challenges.	10
4-6	Organic Conversion Plan: Advanced methods for enhancing soil fertility, soil amendments. Modern methods of composting, vermicomposting, coir pith composting, bio fertilizers, pest and disease management in organic farming; crop rotation in organic horticulture, weed management, botanicals and bio- control agents.	10
7-9	Organic Farming Systems: Natural farming, permaculture, biodynamic farming, Zero budget farming, Homa farming, EM technology.	10
Block-2	**Organic Production Technology**	
10-12	Plantation crops: Coconut, Coffee, Cocoa, Tea.	10
13-14	Major Spices: Black pepper, Cardamom	10
15-17	Ginger, Turmeric, Vanilla	10
18-19	Seed spices: Coriander, Cumin, Fennel, Fenugreek.	10
Block-3	**Certification and Quality Control**	
20-23	Accreditation: Accreditation agencies, certification agencies, procedure of certification, types of certification	10
24-27	Organic standards: Domestic and international standards, NPOP, IFOAM, CODEX, HACCP standards.	10
28-32	Quality control: Participatory Guarantee System (PGS) in quality control, quality control for organic products.	10

Practical:

Practicals No.	Topic
1-2	Enrichment of composts
3-4	Biofertilizers
5-6	Bio control agents
7-8	Biodynamic preparations
9-10	Zero- budget preparations
11-12	Biopesticides

13-14	AMF in organic production
15	Waste management techniques
16	Exposure visits to organic fields, certification and marketing centers.

Suggested Reading

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

Dahama AK. 2005. *Organic Farming for Sustainable Agriculture*. 2nd Ed. Agrobios.

E- manual on *Advances in Cashew Production Technology*. ICAR- Directorate of Cashew Research, Puttur –574 202, D.K., Karnataka.

Gehlot G. 2005. *Organic Farming: Standards, Accreditation, Certification and Inspection*.Agrobios.

Palaniappan SP and Annadarai K. 2003. *Organic Farming: Theory and Practice*. Scientific Publ.

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.

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

Pradeepkumar T, Suma B, Jyothibhaskar and Satheesan KN. 2008. *Management of Horticultural Crops*. New India Publ. Agency.

Sera T, Soccol CR, Pandey A and Roussos S. *Coffee Biotechnology and Quality.* Springer, Dordrecht.

Shivashankar K. 1997. *Food Security in Harmony with Nature*. 3, IFOAM- RD, ASIA, Scientific Conference. 1-4 Dec., 1997, UAS, Bangalore.

Course Title : Marketing and Trade of Plantation, Spices, Medicinaland Aromatic Crops Course Code : PSMA 607
Credit Hours : (2+1)

Theory:

Block / Lec. No.	Topic	Weightage
Block-1	**Importance of marketing and trade in PSMA's**	
1-6	Market opportunities: Market opportunities and challenges in PSMA crops at the domestic and global level, consumption in India's plantation, herbal and spice and other industries, Demand-supply scenario of PSMAs at the national and international level, Marketing and trade in raw materials and value added products.	20
7-12	Marketing strategies: Direct and indirect marketing, niche marketing, specialty markets, market intermediaries and their role, market infrastructure needs, marketing efficiency. market organization, planning, promotion, cost control, contract farming.	20
Block-2	**Marketing Channels**	
13-18	Market organizations: Marketing co-operatives including tribal co- operatives, public private partnerships (PPP), Farmer Producer Companies (FPC) and Farmer Producer Organisations (FPOs).	15
19-24	Supply chain management and total quality management: Good transportation procedures, cold storage facilities, State trading, warehousing and other govt. agencies. Role of commodity boards and export promotion councils in marketing and export of PSMA crops.	15
Block-3	**Entrepreneurship development**	
25-27	Decision making: Risk taking, motivation, importance of planning, monitoring, evaluation and follow up, SWOT analysis, generation, incubation and commercialisation of ideas and innovations. Communication skills, domestic and export market intelligence, export standards. Role of information technology and telecommunication in marketing of PSMAs	15
28-32	Price structure: Price analysis and price forecasting in PSMA crops. policies on export, import and re-export of commodities and value added products, guidelines for marketing of organic produce and organicproducts	15

Practical:

Practicals No.	Topic
1-3	Study of requirement of various raw materials by the plantation, spice and ayurvedaindustries
4-6	Demand supply analysis of various PSMA crops

7-9	EXposure visit to trading centres, eXporters, ware houses, value addition units, etc
10-12	Study of FPOs and FPCs in various crops
13-14	Preparation and evaluation of projects
15-16	Documentation of case studies

Suggested Reading

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

Chinnappa B. 2018. *Economics and marketing of Arecanut in India*. Narendra Publishing House, New Delhi.

CUTS. 2004. *Data base on Medicinal Plants*. CUTS Centre for International Trade, Economics and Environment, Calcutta.

E-manual on *Advances in Cashew Production Technology*. ICAR- Directorate of Cashew Research, Puttur-574 202, D.K., Karnataka.

Holly J and Cheria K. 1998. *The medicinal plant Sector in India*. Medicinal and Aromatic Programme in Asia (MAPPA), New Delhi, India.

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.

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.

Tyagi SK. 2015. *Spices, Plantation Crops, Medicinal and Aromatic plants-a hand book.* New India Publishing Agency.Varmudi. 2001. *Marketing of Spices*. Daya publishing house.

Ved DK and Goraya GS. 2007. *Demand and Supply of Medicinal Plants in India*. NMPB, New Delhi, FRLHT, Bangalore.

e-Resource

www.nmpb.nic.in

Suggested Journals

Sr. No.	*Name of the Journal*	ISSN No.
1	*Annals of Horticulture*	0976-4623
2	*Biological Agriculture and Horticulture*	2165-0616
3	*Current Horticulture*	2455-7560
4	*European Journal of Medicinal Plants*	2231-0894
5	*Horticulture Enviornment and Biotechnology*	2211-3460
6	*Indian Coconut Journal*	0970-0579
7	*Indian Horticulture Journal*	2347-3029
8	*Indian Journal of Arecaunt Spices and Medicinal Plant*	0972-2483
9	*Indian Journal of Arid Horticulture*	2249-5258
10	*Indian Journal of Horticulture*	0974-0112
11	*International Journal of Horticulture*	1927-5803
12	*International Journal of Horticulture, Agriculture and Plant Sciences*	2572-3154
13	*International Journal of Innovative Horticulture*	2320-0286
14	*International Journal of Tea Science*	0972-544
15	*Journal of Applied Horticulture*	0972-1045
16	*Journal of Herbs, Spices, and Medicinal Plants*	1540-3580
17	*Journal of Medicinal and Aromatic Plant Sciences*	0253-7125
18	*Journal of Medicinal Food*	1557-7600
19	*Journal of Medicinal Plant Research*	1996-0875
20	*Journal of Medicinal Plant Studies*	2320-3862
21	*Journal of Plantation Crops*	2454-8480
22	*Journal of Spices and Aromatic Crops*	0971-3328
23	*Medicinal Plants: International Journal of Phytomedicines and Related*	0975-4261
24	*Polycyclic Aromatic Compounds*	1040-6638
25	*Progressive Horticulture*	2249-5258
26	*Rubber Science (Natural Rubber Research)*	2524-3993
27	*Spice India*	0970-5805
28	*The Asian Journal of Horticulture*	0973-4767

Restructured and Revised Syllabus

Horticultural Sciences

M.Sc. & Ph. D. (Horticulture)

in

Post Harvest Management

Submitted by

Broad Subject Coordinator
Associate Dean
College of Horticulture, Mulde
Dr. BSKKV, Dapoli

Discipline Coordinator
Prof. of Horticulture,
College of Horticulture,
Dr. BSKKV, Dapoli

CONTENT

Discipline sub-committee formulated to restructured PG and Ph. D Syllabus of PHM in Maharashtra

The physical (Hybrid mode) meeting of Discipline sub-committee formulated to restructured PG and Ph. D Syllabus of PHM in Maharashtrawas conducted on 07.04.2022 at 10.00 hr under the chairmanship of Dr.C. D. Pawar, Discipline Coordinator and Professor College of Horticulture, Dapoli. Broad subject Coordinator Dr. P. C. Haldavnekar, Associate Dean, College of Horticulture, Mulde also attended the meeting. Following members and invitees of subcommittee attended the meeting and suggested the corrections/suggestions in restructuring and finalizing the ICAR-NCG-BSMA Syllabi for PG degrees (Masters and Ph. D.) for the Post-Harvest Managementdiscipline.

Sr. No.	Name of faculty	Designation	Remarks
1	Dr. C. D. Pawar	Professor, College of Horticulture, Dapoli.	Chairman, Subcommittee ICAR BSMA - PHMand Discipline Coordinator
2	Dr. U. D. Chavan	Professor and Head, Department of Food Science and Technology, MPKV, Rahuri	Member
3	Dr. Mrs. Vijaya Pawar	Associate Professor and Head, College of Food technology, VNMKV, Parbhani	Member
4	Dr. Vishnu Garande	Professor (CAS), Zonal Agricultural Research Station, Ganeshkhind, Pune MPKV, Rahuri	Member
5	Dr. V. S. Khandare	Sr. Research Officer, Vegetable Research Scheme, VNMKV, Parbhani	Member
6	Dr. Vinod Raut	Associate Professor, Department of Horticulture, PDKV, Akola	Member
7	Dr.Abhiman Sawant	Associate Professor and Head, Agricultural Process Engineering, College of Agri. Engineering and Technology, Dapoli	Member
8	Dr. Mrs. Pooja Sawant	Associate Professor, College of Agriculture, Dapoli (Home Science)	Member
9	Dr. Vijay Thorat	Associate Professor, Department of Agril. Economics, College of Agriculture, Dapoli	Member
10	Dr. K. V. Malshe	Associate Professor, College of Horticulture, Dapoli	Member
11	Dr. M. M. Kulkarni	Assistant Professor, College of Horticulture, Dapoli	Member
12	Dr.Mandar Khanvilkar	Assistant Professor, College of Horticulture, Dapoli	Member

Preamble

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 systemsregulating product deterioration and senescence, Innovations in packaging and storagetechnology of fresh produce, Active and smart packaging film for food and Postharvesttreatment, 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 development 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	Credits 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

Note: Courses with *are compulsory along with any one course as per research topic

Common Compulsory Courses: These following courses will be offered preferably as e-courses for all students undergoing Master's degree programme. The Courses, PGS-503 and PGS-505 are already in the form of e-courses.

Course and Credit Requirement

The course structure and minimum credit requirement as evolved through a series ofmeetings and workshops of BSMA-Horticultural Sciences and Review meetings by NCG areas follows:

	Masters' Programme	Doctoral Programme
(i) **Course work**		
Major Courses	20	12
Minor Courses	08	06
Supporting Course(s)	06	05
Common compulsory courses	05	–
Seminar	01	02
(ii) **Comprehensive Exam**	–	Non-credit course
(iii) **Thesis/ Research**	30	75
Total	**70**	**100**

Minor Disciplines: Suggestive list of discipline for minor courses

1. Seed Science and Technology
2. Diary Science
3. Fisheries
4. Biochemistry
5. Forestry
6. Floriculture and Landscaping
7. Vegetable Science
8. Plantation, Spices, Medicinal and Aromatic Crops
9. Processing and Food Engineering

Note: These are the minor disciplines for M.Sc. Students; however some suggestive minor courses included in semester wise layout.

Minor Courses- Suggestive list of minor courses

Course Code	Course title	Credit hours
BIOCHEM 501	Basic Biochemistry	3+1
PFE 504	Horticultural Crops Process Engineering	**2+1**
PFE 505	Storage Engineering and Handling of Agricultural Produce	2+1
PFE 510	Food Processing Technologies	2+1
FPU 508	Chemistry and Processing of Medicinal and Aromatic Plants	2+1

DS 511	Advances in Dairy Processing	3+1
DS 512	Advances in Food Processing	3+1
VSC 513	Processing of Vegetable	1+1
VSC 514	Postharvest Management of Vegetable Crops	2+1

Supporting/Optional Courses:

Supporting/optional courses of 500 series (06 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Statistic
2. Biochemistry
3. Organic Farming
4. Forestry
5. Plant Pathology
6. Plant Physiology
7. Entomology
8. Processing and Food Engineering

Supporting Courses- Suggestive list of Supporting Courses

Course Code	Course title	Credit hours
PP 509	Physiology of Horticulture Crops	2+0
SST 508	Post Harvest Handling and Storage of Seeds	2+1
BIOCHEM 501	Basic Biochemistry	3+1
FPU 508	Chemistry and Processing of Medicinal and Aromatic Plants	2+1
OF 508	Value Chain Management	2+2
OF 509	Marketing	2+0
ENT 511	Post Harvest Entomology	1+1
PL PATH 518	Post-Harvest Diseases	2+1

Deficiency Courses for Agriculture student from B. Sc. (Hons) Horticulture degree program

Course No.	Title of course	Credits
H/PHT - 231	Fundamentals of Food and Nutrition*	1 + 1 = 2
H/FS - 233	Tropical and Subtropical Fruits	2 + 1 = 3
H/VS - 232	Tropical and Subtropical Vegetable crops	2 + 1 = 3
H/FS - 358	Plantation Crops	2 + 1 = 3
H/VS - 243	Spices and Condiments	2 + 1 = 3
H/FL - 231	Commercial Floriculture	2 + 1 = 3

Note: Course with * is compulsory along with any one course as per research topic

Deficiency Courses for Forestry student from B. Sc. (Hons) Horticulture degree program

Course No.	Title of course	Credits
H/PHT - 231	Fundamentals of Food and Nutrition*	1 + 1 = 2
H/PHT – 362	Post-harvest Management of Horticultural Crops*	2 + 1 = 3
H/PHT - 363	Processing of Horticultural Crops*	1 + 2 = 3
H/FS - 233	Tropical and Subtropical Fruits	2 + 1 = 3
H/VS - 232	Tropical and Subtropical Vegetable crops	2 + 1 = 3
H/FS - 358	Plantation Crops	2 + 1 = 3
H/VS - 243	Spices and Condiments	2 + 1 = 3
H/FL - 231	Commercial Floriculture	2 + 1 = 3

Note: Student taking admission from forestry discipline to M. Sc. (PHM) has to complete deficiency courses H/PHT 231, H/PHT 362, H/PHT 363 taught to B. Sc. (Hons.) Horticulture and Student taking admission from agriculture discipline to M. Sc. (PHM) has to complete deficiency courses H/PHT 231 taught to B. Sc. (Hons.) Horticulture.

Common Non Credit PGS Courses

Course code	Course Title	Credits
PGS 501	Library and Information Services	0+1
PGS 502	Technical Writing and Communications Skills	0+1
PGS 503	Intellectual Property and its management in Agriculture	1+0
PGS 504	Basic Concepts in Laboratory Techniques	0+1
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
PGS 506	Disaster Management	1+0

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 quantityand quality after harvest. These produce require integrated approach to arresttheir spoilage and overcome the present day challenges that assimilates millionsof tons annually. Lack of postharvest awareness and absence of sufficient andfunctioning equipment in the postharvest chain result in serious postharvest lossesin developing countries. Clear and comprehensive understanding of postharvestdeteriorative factors is necessary to overcome these challenges. Pre and postharvestmanagement such as good cultural practices, use of improved varieties, good handlingpractices pre and postharvest, temperature and relative humidity management,storage atmosphere management, use of permitted chemicals, design of appropriatepackaging materials and storage structures are some of the control measures usein reducing postharvest losses. Hence this customized course

V. Aim of the course

To impart comprehensive knowledge on management of horticultural produce thusextending the post-harvest life of the produce by various treatments.

The course is organized as follows:

No	Blocks	Units
1	Postharvest management of	I Importance and scopehorticultural produce
		II Regulation of ripening
		IIITreatments for extending shelf life
		IV Handling system and marketing ofhorticultural crops

VI. Theory

Block 1: Postharvest Management of Horticultural Produce

Unit I: History, Importance and scope of Postharvest technology ofhorticultural 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 anddiscoloration in vegetables.

Unit III: Maturity indices for harvest. Harvesting and harvesting tools. Curing Horticultural Sciences–Post-harvest Managementin roots and tubers. Prepackage Operation: Preecooling, washing, sorting, grading of horticultural perishables for

local markets andexport. Postharvest handling of spices, plantation crops, medicinaland 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(Mango/Grapes/Banana/Sweet Orange). Principles of transport, modes of transportation, types ofvehicles 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, flowers,spices and plantationcrops;
- Protective skin coating with wax emulsion and pre and Postharvest treatmentwith fungicides, chemicals and growth regulators to extend the shelf life of fruitsand vegetables;
- Prepackaging of perishables;
- Extension of vaselife of cut flowers by use of chemicals and growth regulators;
- Control of sprouting of potato / 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, vegetablesand flowers;
- Visit to packaging centers;
- Visit to local markets, cooperative organizations, super markets dealing withmarketing 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 tounderstand:

- 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 RuralAreas*-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, ISBN9781498703802.

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 tothe physiology and handling of fruit and vegetables*, CABI Publishing, ISBN9781786391483.

Wills RBH and Golding J. 2017. *Advances in Postharvest Fruit and Vegetable Technology*, CRCPress, 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 activeprocesses of degradation. Numerous physiological and biochemical processescontinuously change the original composition of the crop until which decrease theshelf life of the produce. Postharvest physiology is the scientific study of thephysiology of living plant tissues after picking. It is very much necessary to learnabout it as has direct applications to postharvest handling in establishing thestorage 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 afterharvest and to understand different physiological processes like respiration ripeningThe course is organized as follows:

No	Blocks	Units
1	Biochemistry of perishable	I. Structure and composition of horticulturalproduce
		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, vegetablesand ornamentals.

Unit II: Biochemical changes during development and ripening. StructuralDeterioration of the Produce-cell wall degradation, change in membranelipid.: Biosynthesis of ethylene and its regulation. Ethylene action andripening processes, its perception-action and regulation.

Block 2: Postharvest physiology of perishables

Unit I: Determining maturity and maturity indices. Factors affecting maturity. Ripening processes: eventsof 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 andwater stress during postharvest. Postharvest oxidative stress: activeoxygen species, AOS generation, physiological effects on horticulturalcommodity, 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 TSS, moisture, Titratable acid, sugar, starch, pigments (chlorophyll, carotene, anthocyanin), Vitamin C, protein, phenols and tannins during maturation and ripening in fruits/ vegetables;
- Delay/ Hastening of ripening by ethylene treatments;
- 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, ISBN9781498703802.

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 offruit 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 nutritionalsecurity of the people. Proper packaging and storage will utilize market surplusduring glut season and thus give boost to the food industry. Horticultural produceis highly perishable particularly under tropical conditions of India. The spoilage ofthese 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 packagingmethods
		II. New technologies in packaging

VI. Theory

Block 1: Storage Systems

Unit I: Importance of storage of horticultural produce, present status andfuture scope. Principles and methods of storage – field storagestructures and designs for bulk storage of horticultural produce- onionand potato, etc. Evaporative cool chambers. Physiological changesduring storage.

Unit II: Refrigerated storage – principles of refrigeration, types of refrigerants,refrigeration equipments. Cold storage rooms – Calculation ofrefrigeration 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 CAstorage on the physiology of stored produce. Hypobaric storageprinciple,uses, and requirements. Storage disorders.

Block 2: Packaging

Unit I: Importance of packaging of fresh horticultural produce,present status and future scope. Gaps in packaging concepts. Packagingrequirements of fresh horticultural produce. Packaging patterns andmethods. Food packaging systems: Different forms of packaging suchas rigid, semi-rigid, flexible forms. Traditional, improved and specializedpackages. Paper based packages: corrugated fibre board boxes – rawmaterial and types of boxes. Flexible packaging materials – types andtheir properties. Consumer and intermediate

flexible bulk containers.Testing of flexible packaging material. Barrier properties of packagingmaterials.Cushioning material

Unit 2: New technology in packaging – stretch wrapping system, vacuumpackaging, gas packaging, controlled atmosphere (active and intelligent)packaging, vibra packaging, skin packaging, shrink packaging, smart packaging, Nano Silver packaging,Packaging machines.Quality control and safetyaspects of packaging materials.

VII. Practical

- Study of special storage structures for bulk storage of onion/ potato, etc.;
- Study of storage behaviour of different fruits and vegetables in zero energy coolchamber;
- Determination of refrigeration requirements (capacity) for given quantity of fruitsand 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.
- Visitto special storage structures, cold storage units.
- Study of types of packagingmaterials, types of plastic films and their properties;
- Determination of water vapour transmission rate (WVTR) and gas transmissionrate (GTR) of packaging material;
- Applications of packaging material for fresh fruits and vegetables,flowers, spiceproduce;
- Determination of shelf-life of fresh produce in different types of packages;
- Study of packaging machines – vacuum packaging machine, shrink wrappingmachine, 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 tounderstand:

- 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*, CABIPublishing, 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 SubtropicalFruits 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 and Storage 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 andtheir packaging. Much of the total cost of produce is determined by nature ofpackaging and packaging material used. Packaging cost sometimes exceed the rawmaterial cost, depending on the nature of the produce, time and period. This coursehelps in understanding the packaging interaction with produce, environment andtime. And it also helps to take informed decision on package requirement forhorticulture produce.

V. Aim of the course

To acquaint with the different and packaging systems for processed horticulturalproduce.

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: Principals and functions of packaging; Type of packaging materials; Selection ofpackaging material for different foods; Selective properties of packagingfilm; Methods of packaging and packaging equipment.

Unit II: Mechanical strength of different packaging materials; Printing of packages; Barcodes and other marking; Interactions between packagingmaterial and foods; Environmental and cost consideration in selectingpackaging materials.

Unit III: Manufacture of packaging materials; Potential of bio-compositematerials for food packaging; Packaging regulations; Packaging andfood preservation; Disposal of packaging materials.

Unit IV: Metal cans: types, fabrication, lacquering and tin quality. Doubleseaming 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; Flexiblecontainers; SealingEquipment. Labeling; Aseptic and shrink packaging; Secondary andtransport packaging. Different packaging systems for dehydrated,frozenand processedfruits and vegetables.

Block II: Storage of Processed product

Unit I: Handling and storage of processed product, Chemical changes during storages; Spoilage during storages of processed products

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.
- Chemical changes during storage of processed products.
- Handling and storage studies of processed products.
- Visit to storage unit in processing industry.

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 tounderstand:

- 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 VegetablePreservation
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 moreperishables. Losses in the fruits and vegetables are high and chances to reduce thewaste and enhancing the employability through post-harvest processing are more.The processing includes pre-processing of fruits and vegetables before these are fitto final conversation into processed foods. The food preservation and processingindustry has now become of a necessity than being a luxury. It has an importantrole in conservation and better utilization of fruits and vegetables. In order toavoid the glut and utilize the surplus during the season, it is necessary to employmodern methods to extend storage life for better distribution and also processingtechniques to preserve them for utilization in the off season on both large scale andsmall scale. Hence this customized course.

V. Aim of the course

Understanding spoilage, underlying principles and methods of processing of fruitsand 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 Preservation

Unit I: Introduction, Historical development in food processing, type offood and causes for food spoilage. Basic principles of fruits andvegetables processing;

Unit II: Thermal processing, pH classification of foods, heat resistance ofmicroorganism; Heat resistance of enzymes in foods, Spoilage ofthermal processed food; Containers – canning, rigid tin platesand cans, aluminium cans, glass containers – types; flexiblepackaging materials, Composite can, specification, corrosion ofcans, heat penetration into containers and methods fordetermination of process time.

Unit III: Effects of low temperature on fresh commodities and prepared product. Freezing preservation, freezing points of foods, slow andquick freezing, Cryogenic freezing and frozen food storage. Dryingand dehydration, sun drying solar dehydration, mechanical dryingtypes of driers, osmotic dehydration.

Unit IV: Food fermentation – alcoholic, acetic and lactic fermentation.Pickling and curing; Effect of salt on food preservation, types ofsalt cured products. Traditional and new products; chemicalpreservation, SO2, benzoic acid, sorbic acid, antioxidants and

antibiotics, newer preservatives. Preservation by controlling wateractivity – high sugar products, intermediate moisture food, juice concentrates.

Unit V: Food irradiation, principles, types and sources of radiation, modeof action of ionizing radiation; radiation effect on food constituentsand regulation.

VII. Practical

- List and cost of equipment, utensils, and additives required for small scaleprocessing industry;
- Chemical analysis for nutritive value of fresh and processed fruits and vegetables;
- Preparation and preservation of fruit based beverages and blended products fromfruits 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 andTechnology* (2nd Edition), CRC Press, ISBN 9780849314780.

FAO. 2007. *Handling and Preservation of Fruits and Vegetables by Combined Methods forRural Areas- Technical Manual*. FAO Agricultural Services Bulletin 149.

Fellows PJ. 2009. Food Processing Technology: Principles and Practice (3rd Edition), WoodheadPublishing, 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* (3rdEdition), 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 productsof all commodity technologies used for routine quality control in food industry, andtheir role on nutritional labeling. To develop an understanding and methodologiesof instrumental techniques in food analysis used for objective methods of foodquality 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 andspices. Identification and enumeration of microbial contaminants.

Unit IV: Principles of chromatography (GC, GCMS, HPLC, LCMS),spectrophotometry (Atomic absorption spectrophotometer, ICAPspectrophotometer), ICP-MS, ICPOES, NMR, ESR, amino acid analyser,flame photometry, electrophoresis.

Unit V: Colour measurement in foods, IRGA, Radio-isotopic techniques. Nondestructive quality evaluation (NDQE)- E-nose, E-tongue, machinevision.

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 processedproducts;
- 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 tounderstand:

- 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, SamplePreparations 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.

SemihOtles (Ed). 2016. *Methods of Analysis of Food Components and Additives* (*Chemical andFunctional 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 andplace of harvest to the time and place of consumption, with minimum loss, maximumefficiency and returns to all concerned including grower, processors and consumer.The term 'system' represents a dynamic, complex aggregate of locally interconnectedfunctions or operations within a particular sphere of activity. While, the term pipelineof operations refers to the functional succession of various operations but tends toignore 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 includemixing, 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 thecountry, objectives and importance of preservation, important constraints anddifferent unit operations processing industry which helps in expansion of industryand 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
		II Thermal processes
		III Evaporation
2.	Processing equipment and enzyme	I Processing equipment and facilitieskinetics
		II Enzyme kinetics

VI. Theory

Block 1: Importance and Thermal processes

Unit I: Processing unit- layout and establishment, processing tools. Qualityrequirements of raw materials for processing, preparation of rawmaterial, primary and secondary processing: grading, sorting, cleaning, washing,peeling, slicing and blanching; minimal processing.

Unit II: Preparation of various processed products from fruits, vegetables andflowers; role of sugar, acid and pectin in processed products. Freezing offruits and vegetables. Containers, equipment and technologies incanning.

Unit III: Juice extractions, clarification and preservation, recent advances injuice processing technology, application of membrane technology inprocessing of juices, preparation of fruit beverages and juiceconcentrate.

Block 2: Processing equipment and enzyme kinetics

Unit I: Dehydration of fruits and vegetables using various drying technologiesand equipment, solar drying and dehydration, packaging techniquefor processed products.

Unit II: Quality assurance and storage system for processed products. Nutritivevalue of raw and processed products, Enzyme kineticsplant sanitation and wastedisposal. Types of horticultural and vegetables wastes and their uses,utilization of by- products from fruits and vegetables processingindustries.

VII. Practical

- Handling of harvesting equipments;
- Determination of physical and thermal properties of horticultural commodities;
- Thermal process calculations;
- Particle size analysis,
- Numerical problems in freezing, drying, conveying and calculations pertaining totexture and Rheology;
- Handling of heating equipment, pulper, juice extractor, deaerator, juice filters;
- Processing industries waste treatment;
- Working of a canning unit;
- Visit to commercial processing units and storage units.

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 tounderstand:

- Unit operations of processing
- Planning for domestic as well as commercial storage and processing facilities
- Kinetics of growth and enzyme reaction

X. Suggested Reading

Karel M and Lund DB. 2003. *Physical Principles of Food Preservation* (2nd Edition), CRCPress, 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 havegood appearance and few visual defects, but for them a useful cultivar must scorehigh on yield, disease resistance, ease of harvest, and shipping quality. To receiversand market distributors, appearance quality is most important; they are also keenlyinterested in firmness and long storage life. Although consumers buy on the basis ofappearance and feel, their satisfaction and repeat purchases are dependent upongood edible quality. Assurance of safety of the products sold is extremely importantto the consumers. Hence this customized course.

V. Aim of the course

To understand the quality and safety management system and the process ofsensory analysis for horticultural productsThis 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. Conceptsof quality management: Objectives, importance and functions of qualitycontrol; Quality management systems in India; Sampling proceduresand plans.

Unit II: Food laws and regulations in India, Quality management standards,ISO,BIS, PFA, AGMARK and QMS standards, quality systemcomponents and their requirements.

Block 2: Safety

Unit I: Food safety and standards act (FSSA,2006); Strategies for compliancewith international agri-food standards; Export specification andguidelines by APEDA. Hazard analysis and critical control points(HACCP), design and implementation of an HACCP system, steps inthe 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 evaluationprogramme. Selection of sensory panellists; Factors influencing sensorymeasurements; 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: Designing ofexperiments. Handling and interpretation of Data. Role of sensoryevaluation in product optimization. Relationship between objective andsubjective 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 examinationin 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 indehydrated products;
- Analysis of spices for quality parameters. Evaluation of processed productsaccording 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 differentscales, score cards and tests, Hedonic testing;
- Estimation of colour 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, ISBN9780813819464.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, ISBN9781461358879.

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.

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 beyondbasic nutrition. This course examines the rapidly growing field of functional foodsin the prevention and management of chronic and infectious diseases. It attemptsto provide a unified and systematic account of functional foods by illustrating theconnections among the different disciplines needed to understand foods andnutrients, mainly: food science, nutrition, pharmacology, toxicology andmanufacturing 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 produceThis course is organized as follows:

No	Blocks	Units
1	Functional food and importance	I Introduction, Sources and classification
		II Functional Ingredients
2.	Bioactive Compounds	I Introduction and classes of bioactivecompounds
		II Mechanism of Neuroprotection
3.	Neutraceuticals	1 Introduction, classification, role and healthbenefits

VI. Theory

Block 1: Functional food and importance

Unit I: Functional foods- Introduction, definition, history; Importance, relevanceand need of functional foods. Sources and classification of functionalfoods.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 andeffects of horticultural produce; Herbs, herbal teas, oils, etc. in theprevention and treatment of various diseases. Effect of preservationand processing on functional properties of horticulture produce.

Block 2: Bioactive Compounds

Unit I: Introduction, Classes of bioactive compounds present in fruits andvegetables. 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 andprocessing.

Unit II: Mechanism of neuroprotection by bioactive compounds. Techniques ofExtraction, purification and concentration of bioactive compounds fromfruits and vegetables.Bioactive compound and health benefitsIncorporation of bioactive compounds in foods.

Block 3: Neutraceuticals

Unit I: Nutraceuticals- Introduction, classification of nutraceuticals, dietarysupplements, fortified foods, functional foods and phytonutraceuticals. Role of medicinal and aromatic plants in nutraceutical industry. Health benefits of phytoneutraceuticals.

VII. Teaching Methods/ Activities

- Lectures
- Assignment (Reading/ Writing)
- Exposure visits
- Student presentation

VIII. Learning outcome

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

- 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 Vegetablehytochemicals: Chemistry, Nutritional Value and Stability*, Wiley-Blackwell, ISBN9780813803203.

Senrawat R, Khan KA, Goyal MR and Paul PK. 2018. *Technological Interventions in theProcessing of Fruits and Vegetables*, Apple Academic Press, ISBN 9781771885867.

Vattem DA. 2016. *Functional Foods, Nutraceuticals and Natural Products: Concepts andApplications*. 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 foodservice.To develop Techniques for the development of entrepreneurial skills, positiveself-image and locus of control.

V. Aim of the course

To understand the market channel and appraise entrepreneurship opportunity inpostharvest operations.This course is organized as follows:

No	Blocks	Units
1	Marketing and entrepreneurship	I Entrepreneurshipin processing industry
		II Business Plan
		III MSME Enterprise
		IV Marketing
		V Institutional supports

VI. Theory

Unit I: Entrepreneurship – Concept, need for entrepreneurship – Types ofentrepreneurs - entrepreneurial opportunities in horticultural processingsector-Government schemes and incentives for promotion ofentrepreneurship in processing sector.

Unit II: Writing Business Plan- Business Plan Format for Small and microEnterprises-Generation, incubation and commercialization of businessideas – Environment scanning and opportunity identification.

Unit III: Steps in establishment of MSME Enterprise – Planning of an enterprise– Formulation and project report-Meaning – Importance Componentsand preparation.-Government Formalities and Procedures.

Unit IV: Marketing potential of processed products at domestic and internationallevelcomparative advantage and competitiveness – Market Segmentation, Marketing management-Marketing functions, market informationand market research-Problems in marketing of processed products-Demand and supply analysis of important processed products, Marketing channels – Marketing strategy (product strategy and pricingstrategy)- Supply chain management – Meaning, importance,advantages, supply chain management of important processed products. Branding

Unit V: Institutional support to Entrepreneurship Role of Directorate ofIndustries, District Industries, Centres (DICs), Industrial DevelopmentCorporation (IDC), State Financial corporation (SFCs), Commercialbanks Small Scale Industries Development Corporations (SSIDCs),Khadi and village Industries Commission (KVIC), National SmallIndustries Corporation (NSIC), Small Industries Development Bank ofIndia (SIDBI).

VII. Practical

- Consumer Behaviour towards Processed Foods;
- An Empirical Test-Carrying out the SWOT (Strengths, Weaknesses, Opportunitiesand 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 MSMEPolicies;
- Preparation of business plan and project report 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 tounderstand:

- 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 andPlanning*. 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.

Course Title with Credit Load
Ph.D. (Hort.) in Post-harvest Management

Course Code	Course Title	Credit Hours
PHM 601**	Ripening and Senescence of Fruits and Vegetables	1+1
PHM 602**	Recent Trends in Food Preservation	1+1
PHM 603	Management and Utilization of Horticultural Processing Waste	3+0
PHM604**	Supply Chain Management of Perishables	2+0
PHM 605	Export Oriented Horticulture	2+0
PHM 606	Food Additives	1+1
PHM 607	Advances in Processing of Plantation, Spices, Medicinal and Aromatic Plants	3+0
PHM 608	Value Addition in Ornamental Crops	1+1
	Minor courses	06
	Supporting courses	05
PHM 691	Seminar I	0+1
PHM 692	Seminar II	0+1
PHM 699	Research	0+75
	Total	**100**

*Compulsory among major courses

Minor Disciplines: Suggestive list of discipline for minor courses

1. Seed Science and Technology
2. Diary Science
3. Fisheries
4. Biochemistry
5. Forestry
6. Floriculture and Landscaping
7. Vegetable Science
8. Plantation, Spices, Medicinal and Aromatic Crops
9. Processing and Food Engineering

Minor Courses- Suggestive list of minor courses

Course Code	Course title	Credit hours
SST 603	Physiology and Biochemistry of Seeds	2 (1+1)
PP 602	Signal perception and transduction and regulation of physiological processes	2+0
PFE 604	Agricultural Waste and By-Products Utilization	2+1

Supporting/Optional Courses:

Supporting/optional courses of 600 series (05 credits) will be taken on the decision of the Student Advisory committee from following discipline/courses.

1. Agri Business Management
2. Biochemistry
3. Organic Farming
4. Forestry
5. Plantation, Spices, Medicinal and Aromatic Crops
6. Vegetable Science
7. Floriculture and landscaping
8. Processing and Food Engineering

Supporting Courses- Suggestive list of courses

Course Code	Course title	Credit hours
ABM 607	Value Chain Management in Agribusiness	2+0
ABM 609	International Food and Agri Business	2+0
PSM 604	Advanced Methods in Laboratory Techniques	1+2
VSC 604	Seed Certification, Processing and Storage of Vegetable Crops	2+1
FLS 602	Postharvest Biology of Floricultural Crops	2+1

Course Contents
Ph.D. (Hort.) in Post-harvest Management

I. Course Title : Ripening and Senescence of Fruits and Vegetables
II. Course Code : PHM 601
III. Credit Hours : (1+1)

IV. Why this course?

Fleshy fruit experiences profound physiological, biochemical, and structuralmodifications during ripening to facilitate seed dispersal and to become attractiveand nutritious for human consumption. The metabolic networks regulating fruitripening are very complex, and ethylene appears to be a key factor acting in concertwith other environmental signals and endogenous factors. The classical distinctionbetween climacteric and non-climacteric ripening is now questionable, as differentpatterns of synthesis and sensitivity to ethylene may operate in the ripening ofdifferent fruits. In recent years, much progress has been done in the characterizationof the main biochemical pathways implicated in the different ripening-associatedprocesses and in the identification of key genes controlling these events. This coursehighlights current understanding and advances in the regulation of fruit ripeningand key metabolic pathways associated with the different ripening-related processes,with emphasis on their impact on fruit quality.

V. Aim of the course

To impart knowledge about physiological and molecular changes during senescenceand ripening.

VI. Theory

Unit I: Environmental factors influencing senescence, ripening and post-harvest life of fruits, flowers and vegetables.

Unit II: Molecular mechanism of senescence and ageing.Physiological,biochemical and molecular aspects of senescence and fruit ripening.Senescence associated genes and gene products.

Unit III: Functional and ultra-structural changes in chloroplast membranes,mitochondria and cell wall during senescence and ripening.

Unit IV: Ethylene biosynthesis, perception and molecular mechanism of action;regulatory role of ethylene in senescence and ripening, biotechnologicalapproaches to manipulate ethylene biosynthesis and action.

Unit V: Alternate post-harvest methodology and quality attributes. Scope forgenetic modification of post-harvest life on vegetables and fruits.Uses ofGM crops and ecological risk assessment.

VII. Practical

- Physiological and biochemical changes during ripening and senescence;

- Estimation of ethylene during ripening and senescence;
- Determination of Reactive Oxygen Species and scavenging enzymes;
- Measurement of dark and alternate respiration rates during ripening and senescence;
- Estimation of ripening related enzyme activity, cellulases, pectin methyl esterases, polygalacturonase, etc.

VIII. Teaching Methods/ Activities

- Lectures
- Assignments (Readomg/ writing)
- Student presentation

IX. Learning outcome

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

- Physiological, biochemical and structural changes during ripening and senescence.

X. Suggested Reading

Bartz JA and Brecht JK. 2003. *Post harvest physiology and pathology of vegetables*. MarcelDekker Inc.

Davis PJ. 2004. *Plant Hormone: Biosynthesis, Signal transduction and action*. Kluwer AcademicPublishers.

Dris R and Jain SM. 2004. *Production practices and quality assessment of food crops*, Vol. 4:Post harvest treatment and Technology. Kluwer Academic Publisher.

Khan NA. 2006. *Ethylene action in plants*. Springer Verlag.

Knee M. 2002. *Fruit Quality and its Biological Basis*. Sheffield Academic Press, CRC Press.

Nooden LD. 2004. *Plant cell death processes*. Elsevier Science, USA.

Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Post harvest biology and technology of fruits, vegetables and flowers*. Blackwel Publishing, Iowa, USA.

Seymour G, Taylor J and Tucker G. 1993. *Biochemistry of fruit ripening*. Edited Chapman andHall, London.

Valpuesta V. 2002. *Fruit and vegetable biotechnology*.Woodhead Publishing Limited, Cambridge,England.

I. Course Title : Recent Trends in Food Preservation
II. Course Code : PHM-602
III. Credit Hours : (1+1)

IV. Why this course?

Commendable production with short storage life and strategic selling limits theproduce to huge loss after harvest. To prevent the postharvest loss preservation ofproduce with appropriate technique enhances the finished product shelf life nearly10 to 30 times. Food processing combines raw food ingredients to produce marketable food products that can be easily prepared and served by the consumer. Emergingtechnologies which have already found in the food industry or related sector areHigh pressure processing, pulsed electric fields, ultrasound, and cold plasma. Thebasic principles of these technologies as well as the state of the art concerningtheir impact on biological cells, enzymes, and food constituents.

V. Aim of the course

The present subject imparts knowledge on recent advancement in food preservationtechnologies. The basic principles of preservation technologies as well as the stateof the art concerning theirimpact on biological cells, enzymes and food constituents. Current and potential applications will be discussed, focusing on process-structurefunctionrelationships, as well as recent advances in the food process developmentthat make foods.

The course is organized as follows:

No	Blocks	Units
1	Hurdle technology and recent	I Hurdle technologyadvances
		II Thermal and Non-thermal technology
		III Recent food preservation techniques
2	Enzyme applications and quality	I Enzyme and their applicationsparameters
		II Quality specifications and standards

VI. Theory

Block 1: Hurdle technology and recent advances

Unit I: Hurdle technology, Principles of Hurdle Technology, MinimallyProcessed foods, Intermediate moisture foods, role of water activity infood preservation, Chemicals and biochemicals used in Food Preservation- Natural food preservatives, bacteriocins.

Unit II: Thermal and Non-thermal technology, Advanced Thermal andNon-thermal Technology-Pulsed electric field, microbial inactivation,application, present status and future scope. Fundamentals andApplications of High Pressure Processing to Foods, Advances in Useof High Pressure to Processing and Preservation of Plant Foods,Commercial High-Pressure Equipment. Food Irradiation – an EmergingTechnology.

Unit III: Recent food preservation techniques, Ultraviolet Light and FoodPreservation; Microbial Inactivation by Ultrasound; Use of oscillatingMagnetic Fields. Nonthermal Technologies in Combination with OtherPreservation Factors. Preservation by ohmic heating-Advances in Ohmic Heating and Moderate Electric Field (MEF) Processing;

Radio-Frequency Heating in Food Processing;Current State of MicrowaveApplications to Food Processing.Supercritical Fluid Extraction: AnAlternative to Isolating bioactive compounds.

Block 2: Enzyme applications and quality parameters

Unit I: Enzyme and their applications. Enzyme and their application in foodprocessing, Principles of food biotechnology, fermentation and enzymemediated food processing, production of high value products such asSingle Cell Protein, nutritional additives, pigments and flavours.

Unit II: Quality specifications and standards. Quality parameters andspecifications, Food laws and standards, HACCP, FSSAI amendments,ISO, FDA.

VII. Practical

- Determination of thermal resistance of food spoilage microorganisms;
- Determination of thermal death curve;
- Thermal process calculations;
- Demonstration of hurdle approaches in fruits and vegetables preservation.
- Enumerate the hurdle approaches in food processing;
- Detection of microbes in each hurdle. Study of shelf life of fresh cut produce ineach hurdle;
- Study of fresh cut produce packing, storage temperature and microbial interaction;
- Study of thermal and non thermal application in food preservation;
- Study of moisture content in food their water activity;
- Demonstration of microwave technology in fresh produce preservation and drying;
- Determination of dry matter content in food using microwave technology;
- Study the use of enzymes in different fruit juice extraction, quantification, time –
- Pectinase/cellulose and others;
- Incubation techniques of enzymes using fermenter for juice extractions;
- Group discussions on current market potential of hurdle technology – Prose andcons;
- Visit to advanced food processing unit;
- Visit to SCFE unit.

VIII. Teaching Methods/ Activities

- Lectures
- Assignment (Reading/ Writing)
- Student presentation

IX. Learning outcome

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

- Understand the latest methods and techniques in preservation of food particularlyof horticultural produce

X. Suggested Reading

Barbosa CGV, Pothakamury UR, Palou E and Swanson BG. 1998. *Nonthermal Preservation ofFoods*, Marcel Dekker Inc., ISBN 9780824799793.

Karel M and Lund DB. 2003. *Physical Principles of Food Preservation* (2nd Edition), CRC Press, ISBN 9780824740634.

Sun Da-Wen (Ed.) 2014. *Emerging Technologies for Food Processing* (2nd Edition), Elsevier, ISBN 9780124114791.

Tewari G and Juneja V. 2007. *Advances in thermal and nonthermal food.* Blackwell Publishing,ISBN 9780813829685.

Websites

http://www.sciencepublishinggroup.com/specialissue/specialissueinfo?jo

http://www.ijpab.com/form/2017%20Volume%205,%20issue%206/IJPAB-2017-5-6-363-71.pdf

https://www.omicsonline.org/conferences-list/food-processing-technologies-and-advances-in-foodpreservation

https://www.elsevier.com/books/advances-in-cold-plasma-applications-for-food-safety-andpreservation/bermudez-aguirre/978-0-12-814921-8

I. Course Title : Management and Utilization of HorticulturalProcessing Waste
II. Course Code : PHM-603
III. Credit Hours : (3+0)

IV. Why this course?

Processing of fruit and vegetables generates varying level and kinds of wastagethat can be managed differently. With the rapid progress in establishment ofprocessing industries in our country on account of liberal government policies, theimportance of waste management has become an essential and integral part ofplant design as the inappropriate disposal of wastage has already caused great lossto environment and public health. Food processing is a capital intensive, highenergy and water consuming, and moderate to highly polluting industry. However,one can minimize adverse effects on environment and public health and may alsoaugment profit of processing unit by judicious disposal and utilization of wastematerials. They can be used in composting, cattle feeding and biogas generationand certain types may also be utilized in production of value added products.

V. Aim of the course

Understanding the utilization and efficient management of waste from horticulturalprocessing industry.The course is organized as follows:

No	Blocks	Units
1	Waste treatment and disposal	I Introductionmethods
		II Waste treatment processes
		III Waste disposal methods
2	Valorisation of wastes	I Recovery of useful products
		II Treatment of solid and liquid waste

VI. Theory

Block 1: Waste treatment and disposal methods

Unit I: Introduction: Waste and its consequences in pollution and globalwarming. Need for waste management. Waste and its classificationsand characterization-sampling methods, analysis and standards forwaste discharge. Importance of point and nonpoint sources of wastes,Solid and liquid wastes.

Unit II: Waste treatment processes: BOD, COD, DO, TS VS, ash, and different unit operations in waste treatment processes.

Unit III: Waste disposal methods: Nature of waste from processing industryand their present disposal methods. Waste segregation, Primarysecondary and tertiary waste treatment processes, Conventional andnon-conventional waste treatment processes, aerobic and anaerobicwaste treatment processes.

Block 2: Valorisation of wastes

Unit I: Recovery of useful products andValorization of wastes:Recovery of usefulproducts and by-products from waste, viz., organic acids, bioethanol,biobutanol, colour, essence, pectin, oils, etc. animal feed and singlecell protein.

Unit II: Treatment of solid and liquid waste: Technology of treatment of solid and liquid wastes from fruit and vegetable industries. Immobilizedbioreactor in waste treatment.Anaerobic bioreactor and energyproduction.Circular economics and waste management.

VII. Teaching Methods/ Activities

- Lectures
- Assignments (Reading/ Writing)
- Student presentations

VIII. Learning outcome

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

- Can identify the problems related waste treatments and disposal methods
- Problem related valuation of waste and recycling of waste

IX. Suggested Reading

Arvanitoyannis IS. 2008. *Waste Management for the Food Industries*, Academic Press, ISBN9780123736543.

Joshi VK and Sharma SK. 2011. *Food Processing Waste Management: Treatment and UtilizationTechnology*, New India Publishing Agency, ISBN 9789380235592.

Waldron K. Ed. 2007. *Handbook of waste management and co-product recovery in food processing*,CRC Press, ISBN 9780849391323.

Websites

https://www.cabdirect.org/cabdirect/abstract/20153005486

http://www.3rmanagement.in/service/horticulture-waste-management/

I. Course Title : Supply Chain Management of Perishables
II. Course Code : PHM 604
III. Credit Hours : (2+0)

IV. Why this course?

Supply chain management is the management of the flow of goods and services andincludes all processes that transform raw materials into final products. It involvesthe active streamlining of a business's supply-side activities to maximize customervalue and gain a competitive advantage in the marketplace. SCM represents aneffort by suppliers to develop and implement supply chains that are as efficientand economical as possible. Supply chains cover everything from production toproduct development to the information systems needed to direct these undertakings.Because of this, effective supply chain management also requires changemanagement, collaboration and risk management to create alignment andcommunication between all the entities.

V. Aim of the course

To understand the intricacies of perishable supply chain and its management.The course is organized as follows:

No	Blocks	Units
1	Supply chain management of	I Introductionperishables
		II Intrinsic Issues
		III Support system in supply chain- –Infrastructure
		IV. Support system in supply chain- Finance
		V. Support system in supply chain- Government

VI. Theory

Block 1: Supply chain management of perishables

Unit I: Introduction. Present scenario of supply chain management,Role of supply chain and logistics, Challenges faced insupply chain, Input suppliers, Farm output: Market intermediaries,Processors, Retailers.

Unit II: Intrinsic Issues: Perishability, Quality, Grading, Risk: Sources of risk,Classification of Agricultural risk- Production risk, Market and Pricerisk. Mnagement of risk.

Unit III: Support system in supply chain- Infrastructure: definition, role.Transport network, Cold storage, organised market, etc. Information technology-Enterprise resource planning, E-Choupal, Mobile Technology, web portal on agri-market information.

Unit IV: Support system in supply chain- Financial Systems: Introduction, Roleand Relevance, Problems in Synchronization, Role of Technology; CreditStructure in India -Reserve Bank of India (RBI), NABARD; CommodityMarkets, Corporates in Agribusiness.

Unit V: Support system in supply chain- Role of Government: Introduction;Agencies- As a Direct Player. Measures for improving supply chainand its effectiveness, involvement of organized retailers.

VIII. Teaching Methods/ Activities

- Lectures
- Assignment (Reading/ Writing)
- Student presentations

IX Learning outcome

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

- Can identify the problems related waste treatments and disposal methods

X. Suggested Reading

Chandrasekaran N and Raghuram G. 2014. *Agribusiness Supply Chain Management*, CRCPress, ISBN 9781466516755.

Chopra S and Meindl P. 2007. *Supply chain management: strategy, planning, and operation*(3rd Edition), Pearson Education, Inc.,ISBN 0132086085.

Websites

http://www.scmr.com/
https://blog.kinaxis.com/
http://www.supplychainnetwork.com/
http://supplychaininsights.com/
http://www.supplychain247.com/

I. Course Title : Export Oriented Horticulture
II. Course Code : PHM-605
III. Credit Hours : (2+0)

IV. Why this course?

This course relates the national economy which is dependent on the contributionof the export-oriented income. Export oriented policies and laws must be followed by the growers to meet the requirement of the importing countries.

V. Aim of the course

To acquaint the students with the export oriented requirements of horticulturalcrops.The course is organized as follows:

No	Blocks	Units
1	Product specifications and sanitary	I Introduction measures
		II Produce specifications and standards
		III Export oriented sanitary measures
2	Export related policies	I Export implications
		II Treatment of solid and liquid waste

VI. Theory

Block 1: Product specifications and sanitary measures

Unit I: Introduction: India's position and potentiality in world trade; exportpromotion zones in India. Export and import policy, problem in exportof fresh horticultural produce, export infrastructure (sea port, airport,bulk storage facilities, irradiation, Vapour Heat Treatment, quarantine,transportation, etc.,).quarantine need, major export destination andcompeting nations for selected crops.

Unit II: Produce specifications and standards: Scope, produce specifications,quality and safety standards for export of fruits, viz., mango, grape, litchi, pomegranate, walnut, cashewnut, etc., vegetables, viz., onion, chilli, okra,bitter gourd, gherkin, etc., flowers, viz., rose, carnation, chrysanthemum,gerbera, specialty flowers, etc., cut green and foliage plants.

Unit III: Export oriented sanitary measures: Processed and value-addedproducts, Postharvest management for export including packaging andcool chain; HACCP, Codex alimentarius, ISO certification; APEDA and its role in export, WTO and its implications, sanitary and phytosanitary measures. Codex norms and GAP and SOP for export ofmajor horticultural crops from India.

Block 2: Export related policies

Unit I: Export implications: Export of seed and planting material; implicationsof PBR, treatments of horticultural produce, MRL for export ofhorticultural produce.

Unit II: Export oriented regulatory issues: Agriculture Export Policy, Exportprocedure; EXIM Policy, APMC act, Auction Centres, Regulatory issuesof Ministry of Commerce, GoI.

VII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Student presentation

VIII. Learning outcome

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

- Entry barriers, covering issues such as economies of scale, high capital investments,difficult access to distribution channels and markets, etc.
- Bargaining power of buyers, which relates to issues such as the level of concentrationof buying power, buyers' access to information, switching opportunities and costs,etc.

IX. Suggested Reading

Bartz JA. and Brecht JK. 2002. *Postharvest Physiology and Pathology of Vegetables* (IInd Edition)Marcel Dekkar, Inc, New York.

Bhattacharjee, SK. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Bose TK and Yadav LP. 1989. *Commercial Flowers*. NayaProkash, Kolkata.

Bose TK, MaitiRG, Dhua RS and Das P. 1999. *Floriculture and Landscaping*. NayaProkash.

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

Islam CN. 1990. *Horticultural Export of Developing Countries: Past preferences, future prospectsand policies*. International Institute of Food Policy Research, USA.

Reddy S, Janakiram T. Balaji T, Kulkarni S and Misra RL. 2007. *Hightech Floriculture*. IndianSociety of Ornamental Horticulture, New Delhi.

Sheela VL. 2007. *Flowers in Trade*. New India Publ. Agency.

I. Course Title : Food Additives
II. Course Code : PHM 606
III. Credit Hours : (1+1)

IV. Why this course?

Food additives have been used for centuries to improve and preserve the taste,texture, nutrition and appearance of food. Food additives and preservatives areused in today's food supply to prevent foodborne illness, enable the transportationof food to areas that otherwise wouldn't be possible, and for the efficient manufactureof products to consistently meet the established quality standards. Although theremay be certain ill effects of additives and preservatives in food, they increase itsshelf life and help retain the flavour, colour, and texture. They also help maintainor increase the nutritive value of food. Hence this customized course.

V. Aim of the course

To understand the chemistry of food additives and their functions in food processing. This course is organized as follows:

No	Blocks	Units
1	Quality control of horticultural	I Importance of food additivesproducts
		II Methods of preservation
		III Different additives types
		IV Flavour technology
		V Use of functional ingredients and safety andtoxicological evaluation

VI. Theory

Block 1: Food Additives

Unit I: Importance of food additives in processing and preservation ofhorticultural produce by food additives. Food additives-definitions,classification, international numbering systems and functions.

Unit II: Principles and methods of preservation by use of sugar, salt, spices,essential oils, vinegar, mode of action of chemical preservatives.

Unit III: Antioxidants, colours and flavours (synthetic and natural), emulsifiers,sequestrants, humectants, hydrocolloids, sweeteners, acidulants,buffering salts, anticaking agents, clarifying agents, etc. – uses inhorticulture foods and functions in formulations.

Unit IV: Flavour technology: types of flavours, flavour generated duringprocessing – reaction flavours, flavour composites, stability of flavoursduring food processing, flavour emulsion, essential oils and oleoresins,etc.

Unit V: Uses of enzymes in extraction of juices. Pectic substances and theirrole as jellifying agents.Protein, starches and lipids as functionalingredients, functional properties and applications in horticultural food.Safety and toxicological evaluation of food additives: GRAS-tolerancelevels and toxic levels in foods, LD50 value.

VII. Practical

- Extraction of fruit and vegetable juices using enzymes clarification;
- Role of additives and preservatives in RTS, cordial, squash, concentrate, syrup,jam, jelly, marmalade, ketchup, sauce, preserves, chutneys, pickles, candies,crystallized products;
- Estimation of benzoic acid, sulphur-di-oxide;
- Estimation of pectins.

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 tounderstand:

- Importance of food additives in processing and preservation of horticultural produce
- About Flavour technology
- Safety and toxicological evaluation of food additives

X. Suggested Reading

Branen AL, Davidson PM, Salminen S and Thorngate III JH. 2001. *Food Additives* (2nd Edition),Marcel Dekker Inc., ISBN 0824793439.

DGHS Manual 8: *Manual of Methods of Analysis of Foods-Food Additives*.

Gerorge AB. 1996. *Encyclopedia of Food and Color Additives*. Vol. III. CRCPress.

Madhavi DL, Deshpande SS and Salunkhe DK. 1996. *Food Antioxidants: Technological,Toxicological and Health Perspective*. Marcel Dekker.

Michael and Ash I. 2008. *Handbook of Food Additives* (3rd Edition), Synapse InformationResources, Inc., ISBN 9781934764008.

Nagodawithana T and Reed G. 1993. *Enzymes in food processing*. Academic Press.

Ötleº S. Ed. 2005. *Methods of Analysis of Food Components and Additives*, CRC Press, ISBN 9780849316470.

Taylor AJ. and Linforth RST. 2010. *Food Flavour Technology* (2nd Edition), Wiley- Blackwell, ISBN 9781405185431.

Wood R, Foster L, Damant A and Key P. 2004. *Analytical Methods for Good Sdditives*, CRC Press, ISBN 084932534X.

Websites

Additives and Colours FDA-https://www.fda.gov/food/ingredientspackaginglabeling/foodadditivesingredients/ucm094211.htm

https://www.faia.org.uk/

https://www.eufic.org/en/whats-in-food/category/additives

I. Course Title : Advances in Processing of Plantation, Spices,Medicinal and Aromatic Plants

II. Course Code : PHM-607

III. Credit Hours : (3+0)

IV. Why this course?

This course deals with post-harvest operations, processing and value addition detailsof plantation, spices, medicinal and aromatic plants. This course would be veryuseful for everyone who so ever is interested to know about harvesting and handlingof spices, plantation, medicinal and aromatic plants.

V. Aim of the course

To familiarize with advances in processing of plantation, spices, medicinal andaromatic plants

The course is organized as follows:

No	Blocks	Units
1	Handling and utilization of	I Introductionplantation, spice, medicinal and
		II By product utilizationaromatic plants
		III Value addition of medicinal and aromaticplants
2	Essential oil utilization and their storage	
4.	Recovery of useful products	
5.	Treatment of solid and liquid waste	

VI. Theory

Block 1: Handling and utilization of plantation, spice, medicinal andaromatic plants

Unit I: Introduction: Commercial uses of spices and plantation crops.Introduction to processing and products in plantation and spice crops.Significance of on farm processing and quality of finished products.Processing of major spices, extraction of oleoresin and essential oils. Processing of produce from plantation and spice crops.

Unit II: By product utilization:By product utilization in plantation crops for coir production, mushroom culture, cocopeat, bee keeping, toddytapping, Oil cake production and utilization, vermi-composting, Fuelwood and timber wood from perennial spices and plantation crops(crops, viz., coconut, areca nut, cashew nut, oil palm, palmyrah, date palm, cocoa, tea, coffee, rubber, etc. cardamom, black pepper, ginger,turmeric, chilli and paprika, vanilla, cinnamon, clove, nutmeg, allspice,coriander, fenugreek, curry leaf, etc.).

Unit III: Value addition of medicinal and aromatic plants: Value addition onaromatic oils and medicinal herbs. Principles and practices of differenttypes of extraction – distillation, solvent extraction, enfleurage, soxhlet,supercritical fluid extraction, phytonics, counter current extraction.Commercial uses of essential oils, aroma therapy.Commercialutilization of spent material.

Block 2: Essential oil utilization and their storage

Unit I: Quality determination of essential oils: Qualitative determination ofessential oils. Quality analysis and characterization throughchromatographs.

Unit II: Storage of essential oils: Storage of essential oils. Utilization of spentmaterial of medicinal and aromatic crops in manufacture of agarabatti,organic manures and other useful products. Detoxification of wastematerials. Role of spent material in bio-control of diseases and pest inorganic farming. Role of micro-organisms in conversion of waste in touseful products.

VII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Student presentation

VIII. Learning outcome

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

- Learn utilization and processing of spice, plantation, medicinal and aromatic plants
- Apply appropriate processing technique to the crop related processing technique

IX. Suggested Reading

Afoakwa EO. 2016. *Cocoa Production and Processing Technology*, CRC Press, ISBN9781138033825.

Chakraverty A, Majumdar AS, Raghavan GSV and Ramaswamy HS. 2003. *Handbook ofPostharvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices*, CRC Press, ISBN 9780824705145.

Chi-Tang Ho, Jen-Kun Lin and FereidoonShahidi. 2008. *Tea and Tea Products: Chemistry and Health-Promoting Properties*, CRC Press, ISBN 9780849380822.

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Siddiqui MW. 2015. *Postharvest Biology and Technology of Horticultural Crops: Principles andPractices for Quality Maintenance*, CRC Press, ISBN 9781771880862.

Websites

https://www.cabdirect.org/cabdirect/abstract/20006781145:

https://www.springerprofessional.de/en/value-addition-in-flowers/4657550

I. Course Title : Value Addition in Ornamental Crops
II. Course Code : PHM 608
III. Credit Hours : (1+1)

IV. Why this course?

Ornamental crops provide better income from a unit area with higher profitability.The production of flower crops has increased significantly and there is huge demandfor floricultural products in the world resulting in growing international flowertrade. Value addition in floriculture increases the economic value and consumerappeal of any floral commodity. This course will be useful as a source of incomegeneration.

V. Aim of the course

To acquaint the students about the scope and ways of value addition in ornamentalcrops.

The course is organized as follows:

No	Blocks	Units
1	Value addition of flowers	I Introduction
		II Value addition of flower crops
		III Neutraceuticals from petals
2	Floral arrangements and women	I Floral arrangements empowerment
		II Women empowerment

VI. Theory

Block 1: Value addition of flowers

Unit I: Introduction: Importance, opportunities and prospects of value additionin floriculture; national and global scenario; production and exports,supply chain management.

Unit II: Value addition of flower crops: Dry flower making including potpourries, their uses and trade; extraction technology, uses, sourcesand trade in essential oils; aroma therapy; pigment and natural dyesextraction technology, sources, uses and trade.

Unit III: Neutraceuticals from petals: Pharmaceutical and neutraceuticalcompounds from flower crops; petal embedded hand made paper makingand uses, preparation of products like gulkand, rose water,gulroghan,attar, pankhuri.

Block 2: Floral arrangements and women empowerment

Unit I: Floral arrangements: Floral craft including bouquets, garlands, flowerarrangements, etc. tinting (artificial colouring) of flower crops;

Unit II: Women empowerment: Women empowerment through value added products making.

VII. Practical

- Dry flower making including pot pourries; extraction technology, uses, sourcesand trade in essential oils;
- Pigment and natural dyes extraction technology;
- Pharmaceutical and nutraceutical compounds from flower crops;
- Preparation of products like *gulkand*, rose water, *gulroghan*, *attar*, *pankhuri*;

- Petal embedded handmade paper making;
- Floral craft including bouquets, garlands, flower arrangements, etc.*;*
- Tinting (artificial colouring) of flower crops.

VIII. Teaching Methods/ Activities

- Lecture
- Assignment (Reading/ Writing)
- Student presentation
- Group Work/ Seminars
- Product preparation and income generation assessment

IX. Learning outcome

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

- Will be helpful in converting waste into wonder by making potpourris, greetingcards, etc.
- Students can give training to women and create a source of employment to ruralwomen

X. Suggested Reading

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Gary L. McDaniel. 1989. *Floral design and arrangement*. A Reston Book. Prentice hall. NewJersey.

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Prasad S and Kumar U. 2003. *Commercial Floriculture*. Agrobios.

Randhawa GS and Mukhopadhyay A. 2000. *Floriculture in India*, Allied publishers, India.

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

Salunkhe K, Bhatt NR and Desai BB. 2004. *Postharvest biotechnology of flowers and ornamentalplants*. NayaProkash, Kolkata.

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http://www.vedamsbooks.com/no103218/user_forgot_pass.php

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www.ihc2018.org/en/S29.html

Journals on Postharvest Management of Horticultural Crops

Sr. No.	Name of the Journal	ISSN No.
1.	*Annual Review of Food Science and Technology*	ISSN 19411421, 19411413
2.	*Comprehensive Reviews in Food Science and Food Safety*	ISSN 15414337
3.	*Trends in Food Science and Technology*	ISSN 09242244
4.	*Food Chemistry*	ISSN 03088146
5.	*Food Microbiology*	ISSN 10959998, 07400020
6.	*Postharvest Biology and Technology*	ISSN 09255214
7.	*Food Research International*	ISSN 09639969
8.	*Critical Reviews in Food Science and Nutrition*	ISSN 15497852, 10408398
9.	*Journal of Food Engineering*	ISSN 02608774
10.	*International Journal of Food Microbiology*	ISSN 01681605
11.	*Food Control*	ISSN 09567135
12.	*Innovative Food Science and Emerging Technologies*	ISSN 14668564
13.	*Food and Bioprocess Technology*	ISSN 19355130, 19355149
14.	*LWT-Food Science and Technology*	ISSN 10961127, 00236438
15.	*Journal of Functional Foods*	ISSN 17564646
16.	*Food Quality and Preference*	ISSN 09503293
17.	*Journal of Food Composition and Analysis*	ISSN 08891575, 10960481
18.	*Plant Foods for Human Nutrition*	ISSN 09219668, 15739104
19.	*Current Opinion in Food Science*	ISSN 22147993
20.	*Food Packaging and Shelf Life*	ISSN 22142894
21.	*Journal of the Science of Food and Agriculture*	ISSN 10970010, 00225142
22.	*International Journal of Food Science and Technology*	ISSN 13652621, 09505423
23.	*Journal of Food Science*	ISSN 00221147
24.	*Journal of Food Protection*	ISSN 0362028X
25.	*Phytochemical Analysis*	ISSN 09580344, 10991565
26.	*Food Reviews International*	ISSN 15256103, 87559129
27.	*European Food Research and Technology*	ISSN 14382377, 14382385
28.	*Biosystems Engineering*	ISSN 15375110, 15375129
29.	*Agribusiness*	ISSN 15206297, 07424477
30.	*Journal of Sensory Studies*	ISSN 08878250
31.	*Journal of Texture Studies*	ISSN 00224901
32.	*International Journal of Food Properties*	ISSN 10942912, 15322386
33.	*International Journal of Food Sciences and Nutrition*	ISSN 09637486, 14653478
34.	*Journal of Food Science and Technology*	ISSN 00221155
35.	*Advances in Food and Nutrition Research*	ISSN 10434526
36.	*Journal of Food Process Engineering*	ISSN 17454530, 01458876
37.	*British Food Journal*	ISSN 0007070X
38.	*Journal of Food Quality*	ISSN 01469428, 17454557

39.	*Food Science and Technology International*	ISSN 10820132
40.	*Irish Journal of Agricultural and Food Research*	ISSN 07916833, 20099029
41.	*Journal of Food Processing and Preservation*	ISSN 01458892
42.	*Stewart Postharvest Review*	ISSN 17459656
43.	*International Journal of Food Science*	ISSN 23145765, 23567015
44.	*Food Science and Technology*	ISSN 01012061, 1678457X
45.	*International Food Research Journal*	ISSN 19854668
46.	*International Food and Agribusiness Management Review*	ISSN 15592448, 10967508
47.	*Food Science and Technology Research*	ISSN 13446606
48.	*International Journal of Food Engineering*	ISSN 15563758, 21945764
49.	*Journal of Horticultural Research*	ISSN 23005009, 23533978
50.	*International Journal of Postharvest Technology and Innovation*	ISSN 17447550, 17447569
51.	*Food Technology*	ISSN 00156639
52.	*Open Nutraceuticals Journal*	ISSN 18763960
53.	*Advance Journal of Food Science and Technology*	ISSN 20424868, 20424876