

RESTRUCTURED SYLLABUS AS PER BSMA GUIDELINES - 2022



**Sri Konda Laxman Telangana Horticultural University
Mulugu (Village & Mandal) - 502279
Siddipet District, Telangana State**

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Discipline wise Syllabus

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FRUIT SCIENCE (FSC)

M. Sc. (Hort.) Fruit Science

Code	Course	Cr Hrs
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 in 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

Ph. D.(Hort.) Fruit Science

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
FSC 691	Seminar-I	0+1
FSC 692	Seminar-II	0+1
FSC 699	Research	0+75
Total Credits		100

* Compulsory among major courses

M.Sc. Syllabus

FSC 501: TROPICAL FRUIT PRODUCTION (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

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

The courses are organized as follows:-

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

LEARNING OUTCOMES

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

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, Pineapple, Papaya, Avocado, Jackfruit, Rambutan, Sapota, Annonas, Aonla and Ber

PRACTICALS

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

4. Leaf sampling and nutrient analysis (3)
5. Physiological disorders-malady diagnosis (1)
6. Physico-chemical analysis of fruit quality attributes (3)
7. Field/Exposure visits to tropical orchards (1)
8. Project preparation for establishing commercial orchards (1)

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Bartholomew, D.P., Paull, R.E. and Rohrbach, K.G. 2002. *The Pineapple: Botany, Production, and Uses*. CAB International.
- Bose, T, K., Mitra, S.K. and Sanyal, D., 2002. *Fruits of India – Tropical and Sub-Tropical*. 3rd Edn. Naya Udyog, Kolkata.
- Dhillon, W.S., 2013. *Fruit Production in India*. Narendra Publ. House, New Delhi.
- Iyer, C. P. A. and Kurian, R. M. 2006. *High Density Planting in Tropical Fruits: Principles and Practices*. IBDC Publishers, New Delhi.
- Litz, R.E. 2009. *The Mango : Botany, Production and Uses*. CAB International.
- Madhawa Rao, V. N. 2013. *Banana*. ICAR, New Delhi.
- Midmore, D. 2015. *Principles of Tropical Horticulture*. CAB International.
- Mitra, S. K. and Sanyal, D. 2013. *Guava*, ICAR, New Delhi.
- Morton, J F. 2013. *Fruits of Warm Climates*. Echo Point Book Media, USA.
- Nakasome, H. Y and Paull, R. E. 1998. *Tropical Fruits*. CAB International.
- Paull, R.E. and Duarte, O., 2011. *Tropical Fruits* (Vol. 1). CAB International.
- Rani, S., Sharma, A. and Wali, V. K. 2018. *Guava (Psidium guajava L.)*. Astral, New Delhi.
- Robinson, J.C. and Saúco, V.G. 2010. *Bananas and Plantains*. CAB International.
- Sandhu, S. and Gill, B.S. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi
- Schaffer, B., Wolstenholme, B. N. and Whiley, A. W. 2013. *The Avocado: Botany, Production and Uses*. CAB International
- Sharma, K. K. and Singh, N. P. 2011. *Soil and Orchard Management*. Daya Publishing House, New Delhi.
- Valavi, S.G., Peter, K.V. and Thottappilly, G., 2011. *The Jackfruit*. Stadium Press, USA.

FSC 502: SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

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

The course is organised as follows:-

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

LEARNING OUTCOMES

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

THEORY

Block 1: Introduction

Unit I: Importance and Background: Origin, distribution and importance, major species, rootstocks and commercial varieties of regional, national and international importance, eco- physiological requirements.

Block 2: Agro - Techniques

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

Block 3: Crop Management

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

CROPS

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

PRACTICALS

1. Distinguished features of fruit species, cultivars and rootstocks (2)
2. Demonstration of planting systems, training and pruning (3)
3. Hands on practices on pollination and crop regulation (2)
4. Leaf sampling and nutrient analysis (3)

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

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Chadha, K.L. and Awasthi, R.P. 2005. *The Apple*. Malhotra Publishing House, New Delhi.
- Chadha, T.R. 2011. *A Text Book of Temperate Fruits*. ICAR, New Delhi
- Childers, N. F., Morris, J. R. and Sibbett, G. S. 1995. *Modern Fruit Science : Orchard and Small Fruit Culture*. Horticultural Publications, USA.
- Creasy, G and Creasy L. 2018. *Grapes*. CAB International.
- Davies, F.S. and Albrigo, L.G., 1994. *Citrus*. CAB International.
- Dhillon, W.S., 2013. *Fruit Production in India*. Narendra Publishing House, New Delhi.
- Jackson, D., Thiele, G., Looney, N. E. and Morley-Bunker, M. 2011. *Temperate and Subtropical Fruit Production*. CAB International.
- Ladanyia, M., 2010. *Citrus Fruit : Biology, Technology and Evaluation*. Academic Press.
- Layne, D.R. and Bassi, D. 2008. *The Peach: Botany, Production and Uses*. CABI.
- Menzel, C. M. and Waite, G. K. 2005. *Litchi and Longan: Botany, Production and Uses*. CABI
- Pandey, R. M. and Randey, S. N. 1996. *The Grape in India*. ICAR, New Delhi.
- Rajput, C.B.S. and Haribabu, R.S. 2006. *Citriculture*, Kalyani Publishers, New Delhi.
- Sandhu, S. and Gill, B. S. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi.
- Sharma, R. M., Pandey, S. N. and Pandey, V. 2015. *The Pear - Production, Post-harvest Management and Protection*. IBDC Publisher, New Delhi.
- Sharma, R. R. and Krishna, H., 2018. *Textbook of Temperate Fruits*. CBS Publishers and Distributors Pvt. Ltd., New Delhi.
- Singh, S., Shivshankar, V. J, Srivastava, A. K. and Singh I. P. 2004. *Advances in Citriculture*. NIPA, New Delhi.
- Tromp, J., Webster, A. S. and Wertheim, S. J. 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, M. N. 2009. *Temperate Zone Pomology: Physiology & Culture*. Timber Press, USA.

FSC 503: PROPAGATION AND NURSERY MANAGEMENT IN FRUIT CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

To understand the principles and methods of propagation and nursery management in fruit crops. The course is organised as follows :-

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

LEARNING OUTCOMES

The student would be expected to equip to acquire skills and knowledge on principles and practices of macro and micropropagation and the handling of propagated material in nursery.

THEORY

Block 1: Introduction

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

Block 2: Propagation

Unit I: Conventional Asexual Propagation: Cutting– methods, rooting of soft and hardwood cuttings under mist and hotbeds. Use of PGR in propagation, Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

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

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

Block 3: Nursery

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

PRACTICAL

1. Hands on practices on rooting of dormant and summer cuttings (3)
2. Anatomical studies in rooting of cutting and graft union(1)
3. Hands on practices on various methods of budding and grafting (4)
4. Propagation by layering and stooling (2)
5. Micropropagation- explant preparation, media preparation, culturing – meristem tip culture,

- axillary bud culture, micro-grafting, hardening (4)
6. Visit to commercial tissue culture laboratories and accredited nurseries (2)

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Bose, T. K., Mitra, S. K. and Sadhu, M.K., 1991. *Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash, Kolkatta.
- Davies, F.T, Geneve, R.L. and Wilson, S.B. 2018. *Hartmann and Kester's Plant Propagation-Principles and Practices*. Pearson, USA/PrenticeHall of India. New Delhi.
- Gill, S. S., Bal, J. S. and Sandhu, A. S. 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, K.V., eds., 2008. *Basics of Horticulture*. New India Publishing Agency, New Delhi.
- Rajan, S. and Baby, L.M., 2007. *Propagation of Horticultural Crops*. NIPA, New Delhi.
- Sharma, R.R., 2014. *Propagation of Horticultural Crops*. Kalyani Publishers, New Delhi.
- Sharma, R.R. and Srivastav, M., 2004. *Propagation and Nursery Management*. Intl. Book Publishing Co., Lucknow.
- Singh, S. P. 1989. *Mist Propagation*. Metropolitan Book Co.
- Singh, R. S. 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

FSC 504: BREEDING OF FRUIT CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

To impart comprehensive knowledge on principles and practices of fruit breeding. The course organisation is as under :-

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

LEARNING OUTCOMES

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

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

THEORY

Block 1: Introduction

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

Block 2: Reproductive Biology

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

Block 3: Breeding Approaches

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

CROPS

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

PRACTICAL

1. Exercises on bearing habit, floral biology(2)
2. Pollen viability and fertility studies(1)
3. Hands on practices in hybridization(3)
4. Raising and handling of hybrid progenies(2)
5. Induction of mutations and polyploidy(2)
6. Evaluation of biometrical traits and quality traits(2)

7. Screening for resistance against abiotic stresses (2)
8. Developing breeding programme for specific traits (2)
9. Visit to research stations working on fruit breeding (1)

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Abraham, Z. 2017. *Fruit Breeding*. Agri-Horti Press, New Delhi.
- Badenes, M. L. and Byrne, D. H. 2012. *Fruit Breeding*. Springer Science, New York.
- Dinesh, M. R. 2015. *Fruit Breeding*, New India Publishing Agency, New Delhi.
- Ghosh, S. N. Verma, M. K. and Thakur, A. 2018. *Temperate Fruit Crop Breeding-Domestication to Cultivar Development*. NIPA, New Delhi.
- Hancock, J. F. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. Springer Science, New York.
- Jain, S. N. and Priyadarshan, P. M. 2009. *Breeding Plantation and Tree Crops: Tropical Species*. Springer Science, New York.
- Jain, S. and Priyadarshan, P. M. 2009. *Breeding Plantation and Tree Crops: Temperate Species*. Springer Science, New York.
- Janick, J. and Moore, J. N. 1996. *Fruit Breeding*. Vols. I - III. John Wiley & Sons, USA.
- Kumar, N. 2014. *Breeding of Horticultural Crops: Principles & Practices*. NIPA, N. Delhi.
- Moore, J. N. and Janick, J. 1983. *Methods in Fruit Breeding*. Purdue University Press, USA.
- Ray, P. K. 2002. *Breeding Tropical and Subtropical Fruits*. Narosa Publ. House, New Delhi.

FSC 505: SYSTEMATICS OF FRUIT CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

To acquaint with the classification, nomenclature and description of various fruit crops. The course is organised as under:-

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

LEARNING OUTCOMES

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

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

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 and description of cultivated fruit and nut species and their wild relatives features ; development of plant keys for systematic identification and classification.

Development of fruit crop descriptors- based upon Bioversity International Descriptors, ICAR-NBPGR 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 systematic.

PRACTICALS

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

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- ASHS, 1997. *The Brooks & Olmo Register of Fruit and Nut Varieties*. 3rd Ed. ASHS Press.
- Bhattacharya, B. and Johri, B.M. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Pub. House, New Delhi.
- Pandey, B.P. 1999. *Taxonomy of Angiosperms*. S. Chand & Co. New Delhi.
- Pareek, O.P. and Sharma, S., 2017. *Systematic Pomology*. Scientific Publishers, Jodhpur.
- Sharma, G., Sharma, O.C. and Thakur, B.S. 2009. *Systematics of Fruit Crops*. NIPA, N. Delhi.
- Simpson, M. 2010. *Plant Systematics*. 2nd Edn. Elsevier.
- Spencer, R.R. Cross, R. and Lumley, P. 2003. *Plant Names*. 3rd Ed. *A Guide to Botanical Nomenclature*, CISRO, Australia.
- Srivastava, U, Mahajan, R.K., Gangopadhyay, K.K., Singh, M. and Dhillon, B.S. 2001. *Minimal Descriptors of Agri-Horticultural Crops. I: Fruits*. NBPGR, New Delhi.
- Zielinski, Q. B. 1955. *Modern Systematic Pomology*. Wm. C. Brown Co., Iowa, USA.

FSC 506: CANOPY MANAGEMENT OF FRUIT CROPS (1+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

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

The course organisation is as follows :-

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

LEARNING OUTCOMES

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

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

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

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Bakshi, J.C., Uppal, D.K. and Khajuria, H.N. 1988. *The Pruning of Fruit Trees and Vines*. Kalyani Publishers, New Delhi.
- Chadha, K. L. and Shikhamany, S. D., 1999. *The Grape, Improvement, Production and Post Harvest Management*. Malhotra Publishing House, Delhi.
- Iyer, C. P. A. and Kurian, R. M. 2006. *High Density Planting in Tropical Fruits: Principles and Practices*. IBDC Publishers, New Delhi.
- Pradeep kumar, 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, K. K., 2012. *Canopy Management in Fruits*. ICAR, New Delhi

FSC 507: GROWTH AND DEVELOPMENT OF FRUIT CROPS (2+1)

WHY THIS COURSE?

The underlying principles and parameters of growth and development needs to be understood for harnessing maximum benefits in term of yield and quality. External environment and inherent hormonal and metabolic pathways considerably determine growth dynamics. Thus ,a course is formulated to develop know-how on physiological and physical aspects of growthand development processes.

AIM OF THIS COURSE

To develop comprehensive understanding on growth and development of fruit crops. The course is structured as under:-

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

LEARNING OUTCOMES

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

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

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 impacton 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, brassinosteroids, 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 geneticapproaches in plant growth and development.

PRACTICALS

1. Understanding dormancy mechanisms in fruit crops and seed stratification (2)
2. Techniques of growth analysis (2)
3. Evaluation of photosynthetic efficiency under different environments (2)
4. Exercises on hormone assays (2)
5. Practicals on use of growth regulators (2)

6. Understanding ripening phenomenon in fruits (2)
7. Study on impact of physical manipulations on growth and development (1)
8. Study on chemical manipulations on growth and development (1)
9. Understanding stress impact on growth and development (1)

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Bhatnagar, P. 2017. *Physiology of Growth and Development of Horticultural Crops*. Agrobios (India).
- Buchanan, B., Gruissam, W. and Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*. John Wiley & Sons, NY, USA.
- Dhillon, W.S. and Bhatt, Z. A., 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 Wiley & Sons, NY, USA.
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- Leopold, A.C. and Kriedermann, P.E., 1985. *Plant Growth and Development*. 3rd Ed. McGraw-Hill, New Delhi.
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- Schafeer, B. and Anderson, P. 1994. *Handbook of Environmental Physiology of Fruit Crops*. Vol. 1 & 2. CRC Press. USA.
- Seymour, G. B., Taylor, J. E. and Tucker, G.A., 1993. *Biochemistry of Fruit Ripening*. Chapman & Hall, London

FSC 508: NUTRITION OF FRUIT CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

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

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

LEARNING OUTCOMES

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

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

THEORY

Block 1: Introduction

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

Block 2: Requirements and Applications

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

Block 3: Newer Approaches

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

PRACTICALS

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

TEACHING METHODS / ACTIVITIES

- Class room Lectures
- Laboratory / Field Practicals

- Student Seminars / Presentations
- Field Tours / Demonstrations
- Assignments

RESOURCES

- Atkinson , D., Jackson, J. E. and Sharples, R . O. 1980. *Mineral Nutrition of Fruit Trees*. Butterworth – Heinemann.
- Bould, C., Hewitt, E.J. and Needham, P. 1983. *Diagnosis of Mineral Disorders in Plants Vol.1 Principles*. Her Majesty's Stationery Office, London.
- Cooke, G.W. 1972. *Fertilizers for maximizing yield*. Grenada Publishing Ltd, London.
- Epstein, E. 1972. *Mineral Nutrition of Plants: Principles & Perspectives*. Wiley Eastern Ltd.
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- Mengel, K. and Kirkby, E.A. 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, H.L.S. 1992. *Management of Nutrient Interactions in Agriculture*. Fertilizer Development and Consultation Organization, New Delhi.
- Westerman, R.L. 1990. *Soil Testing and Plant Analysis*, 3rd Ed. Soil Science Society of America, Inc., Madison, WI.
- Yawalkar, K.S., Agarwal, J.P. and Bokde, S. 1972. *Manures and Fertilizers*. 3rd Ed. Agri Horticultural Publishing House, Nagpur.

FSC 509 : BIOTECHNOLOGY OF FRUIT CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

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

S. No.	Blocks	Units
1	General Background	Introduction, History and Basic Principles
2	Tissue Culture	<i>In vitro</i> Culture and Hardening
3	Genetic Manipulation	<i>In vitro</i> Breeding, Transgenics and Gene Technologies

LEARNING OUTCOMES

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

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

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, somatic embryogenesis, synthetic seeds, 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, genetagging, gene editing, achievements of biotechnology in fruit crops.

PRACTICALS

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

6. Development of protocols for mass multiplication(2)
7. Project development for establishment of commercial tissue culture laboratory(1)

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Bajaj, Y.P.S., Eds., 1989. *Biotechnology in Agriculture and Forestry*. Vol. V, *Fruits*. Springer, USA.
- Brown, T.A., 2001. *Gene Cloning and DNA Analysis and Introduction*. Blackwell Publishing, USA.
- Chahal, G.S. and Gosal, S.S., 2010. *Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches*. Narosa, New Delhi.
- Chopra, V.L. and Nasim, A., 1990. *Genetic Engineering and Biotechnology – Concepts, Methods and Applications*. Oxford & IBH, New Delhi.
- Keshavachandran, R. and Peter, K.V. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer*. Orient & Longman, Universal Press, US.
- Keshavachandran, R., Nazeem, P.A., Girija, D., John, P.S. and Peter, K.V. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. Vols. I, II. NIPA, New Delhi.
- Kale, C. 2013. *Genome Mapping and Molecular Breeding in Plant*. Vol 4 Fruit and Nuts. Springer
- Litz, R. E. 2005. *Biotechnology of Fruit and Nut Crops*. CABI, UK.
- Miglani, G.S. 2016. *Genetic Engineering – Principles, Procedures and Consequences*. Narosa Publishing House, New Delhi.
- 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, Kolkata.
- Peter, K.V. 2013. *Biotechnology in Horticulture: Methods & Applications*. NIPA, New Delhi.
- 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*. Platinum Press, UK.

FSC 510 : ORGANIC FRUIT CULTURE (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

To develop understanding on organic production of fruit crops. The course is structured as under:-

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

LEARNING OUTCOMES

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

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

THEORY

Block 1: General Aspects

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

Block 2: Organic Culture

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

Block 3: Certification

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

PRACTICALS

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

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Claude, A. 2004. *The Organic Farming Sourcebook*. Other India Press, Mapusa, Goa, India.
- Dabholkar, S.A. 2001. *Plenty for All*. Mehta Publishing House, Pune, Maharashtra.
- Das, H.C. and Yadav, A. K. 2018. *Advances in Organic Production of Fruit Crops*. Westville Publishing House, New Delhi.
- Deshpande, M.S. 2003. *Organic Farming with respect to Cosmic Farming*. Mrs. Pushpa Mohan Deshpandey, Kolhapur, Maharashtra.
- Deshpande, W. R. 2009. *Basics of Organic Farming*. All India Biodynamic and Organic Farming Association, Indore. M.P.
- Gaur, A.C., Neblakantan, S. and Dargan, K.S. 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, S.P. 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, R.A. and Pathak, R.K. 2017. *Bioenhancers*. Lap Lambert Academic Publishing, A.P.

FSC 511: EXPORT ORIENTED FRUIT PRODUCTION (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

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

The course is organised as under:-

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

LEARNING OUTCOMES

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

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

THEORY

Block 1: Introduction

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

Block 2: Regulations

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

Block 3: Quality Assurance

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

PRACTICALS

1. Export promotion zones and export scenario of fresh fruits and their products(1)
2. Practical exercises on quality standards of fruits for export purpose(2)
3. Quality standards of planting material and seeds(2)
4. Hi-tech nursery in fruits(1)
5. Practicals on ISO specifications and HACCP for export of fruits(3)
6. Sanitary and phyto-sanitary measures during export of horticultural produce(2)
7. Post harvest management chain of horticultural produce for exports(2)

8. Visit to export oriented units/agencies like APEDA, NHB, etc.

TEACHING METHODS / ACTIVITIES

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

RESOURCES

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

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

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

NABARD, Mumbai.<http://apeda.gov.in> <http://nhb.gov.in> <http://indiastat.com>

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

FSC 512: CLIMATE CHANGE AND FRUIT CROPS (1+0)

WHY THIS COURSE?

In the changing climatic scenario, the fruit crops get affected adversely due to one or more unfavourable environmental factors. Shifting of temperate fruits to higher altitudes due to insufficient chilling, occurrence of drought and frost in warmer areas are notable examples. In order to educate on extent of damage and strategies to mitigate the effect of climate change, a course has been formulated.

AIM OF THIS COURSE:

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

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

LEARNING OUTCOMES

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

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

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 gases 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 METHODS / ACTIVITIES

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

➤ Assignments

RESOURCES

Dhillon, W.S. and Aulakh, P.S. 2011. *Impact of Climate Change in Fruit Production*. Narendra Publishing House, New Delhi.

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

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

Rao, G.S.L.H.V. 2008. *Agricultural Meteorology*. Prentice Hall, New Delhi.

Rao, G.S.L.H.V., Rao, G.G.S.N., Rao, V.U.M. and Ramakrishnan, Y.S. 2008. *Climate Change and Agriculture over India*. ICAR, New Delhi.

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

FSC 513: MINOR FRUIT PRODUCTION (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

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

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

LEARNING OUTCOMES

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

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

THEORY

Block 1: Introduction

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

Block 2: Agro-Techniques

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

Block 3: Marketing and Utilization

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

CROPS:

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

PRACTICALS

1. Visits to institutes located in the hot and cold arid regions of the country(2)
2. Identification of minor fruits plants/cultivars(2)
3. Collection of leaves and preparation of herbarium(1)
4. Allelopathic studies(2)
5. Generating know-how on reproductive biology of minor fruits(4)

6. Fruit quality attributes and biochemical analysis(3)
7. Project formulation for establishing commercial orchards in fragile ecosystems(1)

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Ghosh, S. N., Singh, A. and Thakur, A. 2017. *Underutilized Fruit Crops: Importance and Cultivation*. Jaya Publication House, New Delhi.
- Krishna, H. and Sharma, R.R., 2017. *Fruit Production: Minor Fruits*. Daya Publishing House, New Delhi
- Mazumdar, B. C. 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, O. P., Sharma, S. and Arora, R. K., 2007. *Underutilised Edible Fruits and Nuts*, IPGRI, Rome.
- Peter, K.V., 2010. *Underutilized and Underexploited Horticultural Crops*. NIPA, New Delhi.
- Rana, J. C. and Verma, V. D. 2011. *Genetic Resources of Temperate Minor Fruit (Indigenous and Exotic)*. NBPGRI, New Delhi.
- Saroj, P. L. and Awasthi, O. P., 2005. *Advances in Arid Horticulture, Vol. II: Production Technology of Arid and Semiarid Fruits*. IBDC, Lucknow.
- Saroj, P. L., Dhandar, D. G. and Vashishta, B.B. 2004. *Advances in Arid Horticulture, Vol.-1 Present Status*. IBDC, Lucknow.
- Singh *et al.*, 2011. *Jamun*. ICAR, New Delhi.

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FSC 601: INNOVATIVE APPROACHES IN FRUIT BREEDING (3+0)

WHY THIS COURSE?

Modern day fruit culture witnesses rapid changes in production technologies and market trends. Ever changing environment and consumer preferences warrant constant development and adoption of genetically improved varieties. There is more thrust on novelty and distinctness in view of ever increasing competition with enhanced emphasis on tailor made and trait specific designer varieties and rootstocks. The course is thus designed to integrate updated information on inherent breeding systems and innovative gene manipulation technologies enhancing breeding efficiency.

AIM OF THIS COURSE:

To update knowledge on current trends and innovative approaches in fruit breeding. The structural organisation of the course is as under:-

S. No.	Blocks	Units
1	Introduction	Current Trends and Status
2	Genetic Mechanisms	Inheritance Patterns and Breeding Systems
3	Breeding for Specific Traits	Plant Architecture, Stress Tolerance and Fruit Quality
4	Fast- Track Breeding	Transgenics, Markers and Genomics

LEARNING OUTCOMES

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

- Develop updated knowledge on current breeding objectives and trends
- Equip with information on innovative approaches enhancing breeding efficiency

THEORY

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, chimeras, 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, fruit keeping wquality attributes, stress tolerance, crop specific traits ; use of apomixis, gene introgression and wide hybridization (alien genes).

Block 4: Fast- Track Breeding

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

CROPS:

Mango, banana, guava, papaya, Citrus, grapes, pomegranate, litchi, apple, pear, strawberry, kiwifruit, plums, peaches, apricot, cherries, nectarines, nut crops

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Al-Khayari , J., Jain, S. N. and Johnson, D. V. 2018. *Advances in Plant Breeding Strategies*. Vol. 3: *Fruits*. Springer
- Badenes, S. and Byrne, D.H. 2012. *Fruit Breeding*. Springer.
- Hancock, J. F. 2008. *Temperate Fruit Crop Breeding: Germplasm to Genomics*. Springer
- Kole, C. and Abbott, A. G. 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, S. N. and Priyadarshan, P. M. 2009. *Breeding Plantation and Tree Crops: Tropical Species; Temperate Species*. Springer -Verlag.
- Janick, J. and Moore, J.N., 1996. *Fruit Breeding*. Vols.I-III. John Wiley & Sons, USA.
- Orton, T. 2019. *Methods in Fruit Breeding*. Elsevier.
- Singh, S.K., Patel, V.B., Goswami, A.K., Jai Prakash and Chavlesh Kumar.2019. *Breeding of Perennial Horticultural Crops*. Biotech Books. Delhi

FSC 602: MODERN TRENDS IN FRUIT PRODUCTION (3+0)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

To keep abreast with latest developments and trends in production technologies of tropical, subtropical and temperate fruits.

The course structure is as follows:-

S.No.	Blocks	Units
1	Introduction	General Concepts and Current Scenario
2	Advanced Technologies	Propagation, Planting Systems and Crop Regulation
3	Management Practices	Overcoming Stress and Integrated Approaches

LEARNING OUTCOMES

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

- Updated knowledge on current trends in fruit production.

Block 1: Introduction

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

Block 2: Advanced Technologies

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

Block 3: Management Practices

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

CROPS:

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

TEACHING METHODS / ACTIVITIES

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

RESOURCES

Bartholomew, D.P., Paull, R.E. and Rohrbach, K.G. eds., 2002. *The Pineapple: Botany, Production, and Uses*. CAB International.

Bose, T.K., Mitra, S.K. and Sanyal, D., Eds., 2002. *Fruits of India – Tropical and Sub-Tropical*. 3rd

Ed. Vols. I, II. Naya Udyog, Kolkata, India.

Dhillon, W.S. and Bhatt, Z. A., 2011. *Fruit Tree Physiology*. Narendra Publishing House, New Delhi.

Dhillon, W.S., 2013. *Fruit Production in India*. Narendra Publishing House, New Delhi.

Gowen, S., 1995. *Bananas and Plantains*. Chapman & Hall Publication, USA.

Litz, R.E. ed., 2009. *The Mango: Botany, Production and Uses*. CAB International.

Peter, K. V. 2016. *Innovations in Horticulture*. NIPA, New Delhi.

Robinson, J.C. and Saúco, V.G., 2010. *Bananas and Plantains* (Vol. 19). CAB International.

Samson, J.A., 1980. *Tropical Fruits*. Longman, USA.

Sharma, R.R. and Krishna, H. 2014. *Fruit Production: Major Fruits*. Daya Publishing House, Delhi.

Singh, S., Shivankar, V.J., Srivastava, A.K. and Singh, I.P. 2004. *Advances in Citriculture*. Jagminder Book Agency, New Delhi.

Stover, R.H. and Simmonds, N.W. 1991. *Bananas*. Longman, USA

Chadha, K.L., Ahmed, N., Singh, S.K., Kalia P. 2016. *Temperate Fruits and Nuts- Way Forward for Enhancing Production and Quality*. Daya Publishing House, New Delhi

Childers, N. F., Morris, J. R. and Sibbett, G. S. 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, N. E. 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, A. S. and Wertheim, S. J. 2005. *Fundamentals of Temperate Zone Tree Fruit Production*. Backhuys Publishers, Lieden, The Netherlands.

Westwood, M. N. 2009. *Temperate Zone Pomology : Physiology and Culture*. 3rd Edn. Timber Press, USA.

FSC 603: RECENT DEVELOPMENTS IN GROWTH REGULATION (3+0)

WHY THIS COURSE?

Technological advancements have resulted in deeper understanding of growth and developmental processes in plants. There is equal and just need to apply these in fruit crops for harnessing maximum benefits in term of yield and quality. So a course has been designed to provide latest information on physiological and biochemical aspects of growth and development.

AIM OF THIS COURSE:

To develop updates on recent advances in growth regulation of fruit crops. Structure of the course is as under:-

S. No.	Blocks	Units
1	Introduction	Current Concepts and Principles
2	Growth Substances	Phytohormones and Growth Regulators
3	Growth and Development	Regulation of Developmental Processes

LEARNING OUTCOMES

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

- Complete understanding of growth dynamics in various fruit crops
- Know-how on manipulation of growth and development processes.

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 METHODS / ACTIVITIES

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

RESOURCES

Bhatnagar, P. 2017. *Physiology of Growth and Development of Horticultural Crops*. Agrobios (India).

Buchanan, B., Gruissam, W. and Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*.

John Wiley & Sons, US.

Fosket, D.E. 1994. *Plant Growth and Development : A Molecular Approach*. Academic Press, USA.

Leopold, A.C and Kriedermann, P.E., 1985. *Plant Growth and Development*. 3rd Ed. McGraw-Hill, US.

Richard N. Artica, 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, F.B. and Ross, C.W., 1992. *Plant Physiology*. 4th Ed. Wadsworth Publication.

FSC 604: ADVANCED LABORATORY TECHNIQUES

(1+2)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

To familiarize with the laboratory techniques for analysis of fruit crops. The organisation of the course is as under :-

S. No.	Blocks	Units
1	General Aspects	Safety Measures and Laboratory Maintenance
2	Qualitative and Quantitative Analysis	1. Destructive and Non-destructive Analysis Methods 2. Chromatographic and microscopic Analysis 3. Sensory Analysis

LEARNING OUTCOMES

The students would be expected to develop skills and expertise on

- Upkeep of laboratories and handling of research instruments
- Principles and methods of various analysis

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.

PRACTICALS

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

8. Non-destructive determination of colour, ascorbic acid, vitamins, carotenoids, sugars and starch(2)
9. Estimation of rate of ethylene evolution using gas chromatograph (GC) (2)
10. Use of advanced microscopes (fluorescent, scanning electron microscope, phasecontrast, etc.) (2)

TEACHING METHODS / ACTIVITIES

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

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 & 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. *Post Harvest Technology of Fruits and Vegetables*. Blackwell Sciences. USA.

FSC 605: ARID AND DRYLAND FRUIT PRODUCTION (2+0)

WHY THIS COURSE?

Arid and dryland regions are known for growing an array of delicious and nutritious fruits (e.g. date palm, aonla, ber etc). Over the years, notable progress has been made in respect of domestication and technological advancements. Thus a course has been developed.

AIM OF THIS COURSE:

To keep abreast with latest developments and trends in production technology of arid and dryland fruit crops.

The course is organised as under:-

S. No.	Blocks	Units
1	Introduction	General Concepts and Current Scenario
2	Advanced Technologies	Propagation, Planting Systems and Crop Regulation
3	Management Practices	Stress Mitigation and Integrated Approaches

LEARNING OUTCOMES

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

- Fruit crops adopting to arid and drylands and their features
- Specific cultivation and management practices

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, Annonas, ber, bael, jamun, date palm, cactus pear, khejri, kair, pilu, lasoda, manila, tamarind, monkey jack, mahua, khirni, amra, seabuckthorn, chilgoza, cafel, rhododendron, box myrtle, chironji, phalsa, karonda, woodapple, paniala and other minor fruits of regional importance

TEACHING METHODS / ACTIVITIES

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

➤ Assignments

RESOURCES

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

FSC 606: ABIOTIC STRESS MANAGEMENT IN FRUIT CROPS (2+1)

WHY THIS COURSE ?

Low soil fertility coupled with unpredictable and unfavourable environments often result in stress conditions. Non-availability of optimum level of inputs and congenial weather necessitates the development of suitable management practices to overcome various abiotic stresses. Hence a course is customized.

AIM OF THIS COURSE

To update knowledge on recent trends in management of abiotic stresses in fruit crops. The course is organised as follows:-

S. No.	Blocks	Units
1	Introduction	Basic Aspects and Principles
2	Stress Impact	Assessment, Physiology and Performance
3	Stress Management	Mitigation Measures and Conservation Practices

LEARNING OUTCOMES

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

- Various types of abiotic stresses and their effects
- Physiological processes underlying abiotic stresses
- Management and conservation practices to overcome stress

THEORY

Block 1: Introduction

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

Block 2: Stress Impact

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

Block 3: Stress Management

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

PRACTICALS

1. Seed treatment /hardening practices (2)
2. Container seedling production(2)
3. Analysis of soil moisture estimates (FC, ASM, PWP) (1)
4. Analysis of plant stress factors, RWC, chlorophyll fluorescence, chlorophyll stability index, ABA content, plant waxes, stomatal diffusive resistance, transpiration, photosynthetic rate etc. under

- varied stress situations(5)
5. Biological efficiencies, WUE, solar energy conversion and efficiency(2)
 6. Crop growth sustainability indices and economics of stress management(2)
 7. Visit to orchards and watershed locations(2)

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- Blumm, A. 1988. *Plant Breeding for Stress Environments*. CRC Publication, USA.
- Christiansen, M.N. and Lewis, C.F. 1982. *Breeding Plants for Less Favourable Environments*. Wiley International Science, USA.
- Kanayama, Y. And Kochetor. 2015. *Abiotic Stress Biology in Horticultural Plants*. Springer.
- Kramer, P.J., 1980. *Drought Stress and the Origin of Adaptation*. In: *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons, USA.
- Maloo, S.R. 2003. *Abiotic Stress and Crop Productivity*. Agrotech Publ. Academy, India.
- Nickell, L.G. 1983. *Plant Growth Regulating Chemicals*. CRC Publication, USA.
- Rao. N.K.S., Shivashankar, K.S. and Laxman, R.H. 2016. *Abiotic Stress Physiology of Horticultural Crops*. Springer.
- Turner, N.C. and Kramer, P.J. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons, USA.

FSC 607 : BIODIVERSITY AND CONSERVATION OF FRUIT CROPS (2+1)

WHY THIS COURSE?

The availability of pertinent gene pool is of utmost importance to mitigate adverse climate and to counter diseases and pests. In addition, specific gene sources (germplasm) would always be a necessity to develop superior genotypes. Considering the importance of conserving biodiversity in fruit crops for future use, the course has been designed.

AIM OF THIS COURSE:

To understand the status and magnitude of biodiversity and strategies in germplasm conservation of fruit crops.

The course is organised as follows :-

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

LEARNING OUTCOMES

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

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&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.

PRACTICALS

1. Documentation of germplasm- maintenance of passport data and other records of accessions (2)
2. Field exploration trips and sampling procedures(2)
3. Exercise on *ex situ* conservation – cold storage, pollen/seed storage(2)
4. Cryopreservation(2)

5. Visits to National Gene Bank and other centers of PGR activities(2)
6. Detection of genetic constitution of germplasm(2)
7. Germplasm characterization and evaluation using a standardised DUS test protocol(2)
8. Special tests with biochemical and molecular markers(2)

TEACHING METHODS / ACTIVITIES

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

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 Jr, J. R. 1991. *Genetic Resources of Temperate Fruit and Nut Crops*. ISHS, Belgium.
- Peter, K.V. 2008. *Biodiversity of Horticultural Crops*. Vol. II. Daya Publ. House, Delhi.
- Peter, K.V. 2011. *Biodiversity in Horticultural Crops*. Vol. III. Daya Publ. House, Delhi.
- Rana, J. C. and Verma, V. D. 2011. *Genetic Resources of Temperate Minor Fruits (Indigenous and Exotic)*. NBPGR, New Delhi.
- Rajasekharan, P. E., 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

FSC 608: SMART FRUIT PRODUCTION (2+0)

WHY THIS COURSE?

In the era of automation and mechanization, several recent innovations have direct applications in fruit growing. Thus a need is felt to have course on smart innovations.

AIM OF THIS COURSE

To acquire knowledge on hi-tech innovations useful in fruit crops. The course is structure is as under:-

S. No.	Blocks	Units
1	Introduction	Importance and Overview
2	Crop Modelling and Forecasting	GIS, Sensors and Wireless System
3	Nanotechnology	Concepts and Methods
4	Innovative Approaches	Mechanization, Automation and Robotics

LEARNING OUTCOMES

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

THEORY

Block 1: Introduction

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

Block 2: Crop Modelling and Forecasting

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

Block 3: Nanotechnology

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

Block 4: Innovative Approaches

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

TEACHING METHODS / ACTIVITIES

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

RESOURCES

- 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, E. W. 2013. *Automation, Mechanization and Robotics in Horticulture*. In: Workshop on Emerging Postharvest Technologies. UC, Davis, USA.
- <http://horticulture.ucdavis.edu> – Innovative Technology for Horticultural Department.
- Prasad, S., Singh, D. and Bhardwaj, R. L. 2012. *Hi-Tech Horticulture*. Agrobios (India).
- Peter, K. V. 2016. *Innovations in Horticulture*. NIPA, New Delhi.
- 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.

SUGGESTED JOURNALS

Sr. No.	Name of the Journal	ISSN No.
1	<i>Advances in Horticultural Science</i>	0394-6169
2	<i>Acta Horticulturae</i>	0567-7572
3	<i>American Journal of Enology and Viticulture</i>	0002-9254
4	<i>Annals of Arid Zone</i>	0570-1791
5	<i>Annals of Horticulture</i>	0974-8784
6	<i>Biodiversity and Conservation</i>	0960-3115
7	<i>Current Horticulture</i>	2347-7377
8	<i>European Journal of Horticultural Science (Gartenbauwissenschaft)</i>	1611-4426
9	<i>Fruits</i>	0248-1294
10	<i>Genetic Resources and Crop Evolution</i>	0925-9864
11	<i>Horticultural Plant Journal</i>	2488-0141
12	<i>Horticulture Environment and Biotechnology</i>	2211-3452
13	<i>HortScience</i>	0018-5345
14	<i>Indian Horticulture Journal</i>	2249-6823
15	<i>Indian Journal of Arid Horticulture</i>	Naas-1234
16	<i>Indian Journal of Dryland Agricultural Research & Development</i>	0971-2062
17	<i>Indian Journal of Horticulture</i>	0972-8538
18	<i>International Journal of Fruit Science</i>	1553-8621
19	<i>International Journal of Horticulture</i>	1927-5803
20	<i>International Journal of Innovative Horticulture</i>	2320-0286
21	<i>Journal of Applied Horticulture</i>	0972-1045
22	<i>Journal of Horticultural Research</i>	2300-5009
23	<i>Journal of Horticultural Science and Biotechnology (Journal of Horticultural Science, England)</i>	1462-0316
24	<i>Journal of Horticultural Sciences</i>	0973-354X
25	<i>Journal of Horticulture</i>	2376-0354
26	<i>Journal of The American Society for Horticultural Science</i>	0003-1062
27	<i>Journal of Tree Fruit Production</i>	1055-1387
28	<i>New Zealand Journal of Crop and Horticultural Science</i>	0114-0671
29	<i>Progressive Horticulture</i>	0970-3020
30	<i>Scientia Horticulturae</i>	0304-4238
31	<i>The Asian Journal of Horticulture</i>	0973-4767
32	<i>The Journal of American Pomological Society</i>	1527-3741

Vegetable Science (VSC)

M. Sc. (Hort.) Vegetable Science

Code	Course title	CreditHours
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	2+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 (NOT OFFERED)	2+1
VSC 513	Processing of Vegetable crops	1+1
VSC 514	Postharvest Management of Vegetable Crops	2+1
Minor Courses		08
Supporting Courses		06
Common compulsory courses		05
VSC 591	Seminar	0+1
VSC 599	Research	0+30
Total Credits		70

* Compulsory among major courses

Ph. D.(Hort.) Vegetable Science

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 seeds	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
VSC 691	Seminar I	0+1
VSC 692	Seminar II	0+1
VSC 699	Research	0+75
Total Credits		100

* Compulsory among major courses

M. Sc. Syllabus

VSC 501: PRODUCTION OF COOL SEASON VEGETABLE CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

To impart knowledge and skills on advancement in production technology of cool season vegetable crops
The course is constructed given as under:

S. No.	Block	Unit
1	Production of cool season vegetable crops	1. Bulb and tuber crops
		2. Cole crops
		3. Root crops
		4. Peas and beans
		5. Leafy vegetables

LEARNING OUTCOMES

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

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

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 (grading, storage, packaging and marketing), pest and disease management and production economics of crops.

Unit I: *Bulb and tuber crops*- Onion (including kharif onion production), garlic and potato

Unit II: *Cole crops*- Cabbage (and red cabbage), cauliflower, kohlrabi, broccoli, Brussels sprouts and kale

Unit III: *Root crops*- Carrot, radish, turnip and beetroot

Unit IV: *Peas and beans*- Garden peas and broad bean

Unit V: *Leafy vegetables*- Spinach, palak, 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 METHODS/ACTIVITIES

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

RESOURCES

- Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G., 2003. Vegetable crops. Vols. I-III. Naya udyog.
- Bose, T.K., Som, M.G. and Kabir, J. (Eds.). 1993. Vegetable crops. Naya Prokash.
- 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 publishers.
- Gopalakrishnan, T.R., 2007, Vegetable crops. New India Publ. Agency.
- Hazra, P. and Banerjee M.K. and Chattopadhyay, A., 2012, Varieties of vegetable crops in India, (Second edition), Kalyani Publishers, Ludhiana , 199 p
- Hazra, P., 2016, Vegetable science. 2nd edn, Kalyani Publishers, Ludhiana.
- Hazra, P., 2019, Vegetable production and technology. New India publishing agency, New Delhi.
- Hazra, P., Chattopadhyay, A., Karmakar K. and Dutta, S., 2011, Modern technology for vegetable production, New India publishing agency, New Delhi, 413p
- Rana, M.K., 2008, Olericulture in India. Kalyani Publ.
- Rana, M.K., 2008, Scientific cultivation of vegetables. Kalyani Publ.
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- 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.
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- 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.

VSC 502: PRODUCTION OF WARM SEASON VEGETABLE CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

To impart knowledge and skills on advancement in production technology of warm season vegetable crops
The course is constructed given as under:

S.No	Block	Unit
1.	Production of warm season vegetable crops	1. Fruit vegetables
		2. Beans
		3. Cucurbits
		4. Tuber crops
		5. Leafy vegetables

LEARNING OUTCOMES

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

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

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, training and pruning in indeterminate varieties, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, storage, packaging and marking), pest and disease management and economics of crops.

Unit I: *Fruit vegetables*- Tomato, brinjal, hot pepper, sweet pepper and okra

Unit II: *Beans*- French bean, Indian bean (Sem), cluster bean and cowpea

Unit III: *Cucurbits*- Cucumber, melons, gourds, pumpkin and squashes

Unit IV: *Tuber crops*- Sweet potato, elephant foot yam, tapioca, taro and yam

Unit V: *Leafy vegetables*- Amaranth, sorrel, rosella, portulaca and drumstick

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 METHODS/ACTIVITIES

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

RESOURCES

- Bose, T.K., Kabir, J., Maity, T.K., Parthasarathy, V.A. and Som, M.G., 2003, Vegetable crops. Vols. I-III. Naya Udyog.
- Bose, T.K., Som, M.G. and Kabir, J. (Eds.), 1993, Vegetable crops. Naya Prokash.
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- Chadha, K.L. (Ed.), 2002, Hand book of horticulture. ICAR.
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- 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.

VSC 503: GROWTH AND DEVELOPMENT OF VEGETABLE CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

To teach the physiology of growth and development of vegetable crops The course is constructed given as under:

Block	Unit
Growth and development of vegetable crops	1. Introduction and phytohormones
	2. Physiology of dormancy and germination
	3. Abiotic factors
	4. Fruit physiology
	5. Morphogenesis and tissue culture

LEARNING OUTCOMES

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

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

THEORY

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

Unit II: *Physiology of dormancy and germination*- Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellins, cytokinins and abscisic 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*- Role of climate on growth and development, 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, potato, cucumber and sweet pepper

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Bleasdale, J.K.A., 1984, Plant physiology in relation to horticulture (2nd Edition) MacMillan.
- Gupta, U.S., Eds., 1978, Crop physiology. Oxford and IBH, New Delhi.
- Kaloo, G. 2017. Vegetable grafting: Principles and practices. CAB International
- Krishnamoorti, H.N., 1981, Application growth substances and their uses in agriculture. Tata McGraw Hill, New Delhi.
- Leopold, A.C. and Kriedemann, P. E., 1981, Plant growth and development, Tata McGraw-Hill, New Delhi.
- 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., (Eds), 2008, Basics of horticulture. New India publication agency, New Delhi.
- Rana, M.K., 2011. *Physio-biochemistry and Biotechnology of Vegetables*. New India Publishing Agency, Pritam Pura, New Delhi.
- Saini *et al.* (Eds.), 2001, Laboratory manual of analytical techniques in horticulture. Agrobios, Jodhpur.
- Wien, H.C. (Eds.), 1997, The physiology of vegetable crops. CAB International.

VSC 504: PRINCIPLES OF VEGETABLE BREEDING (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

To teach basic principles and practices of vegetable breeding The course is constructed given as under:

S.No.	Block	Unit
1.	Principles of vegetable breeding	1. Importance and history
		2. Selection procedures
		3. Heterosis breeding
		4. Mutation breeding
		5. Polyploid breeding
		6. Ideotype breeding

LEARNING OUTCOMES

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

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

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 (including inter-specific hybridization); Genetic architecture; Breeding for biotic stress (diseases, insect pests and nematode), abiotic stress (temperature, moisture and salt) resistance and quality improvement; Breeding for water use efficiency (WUE) and nutrients use efficiency (NUE)

Unit III: *Heterosis breeding*- Types, mechanisms and basis of heterosis, facilitating mechanisms like male sterility, self-incompatibility and sex forms

Unit IV: *Mutation and Polyploidy breeding*; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment

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

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 METHODS/ACTIVITIES

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

RESOURCES

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

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

Kole, C.R. 2007, Genome mapping and molecular breeding in plants-vegetables. Springer, USA.

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Prohens, J. and Nuez, F., 2007, Handbook of plant breeding-vegetables (Vol I and II). Springer, USA.

Singh, B.D., 2007, Plant breeding- principles and methods (8th edn.). Kalyani Publishers, New Delhi.

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VSC 505: BREEDING OF SELF POLLINATED VEGETABLE CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

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

The course is constructed given as under:

S.No.	Block	Unit
1.	Breeding of self pollinated vegetablecrops	1. Potato
		2. Fruit vegetables
		3. Garden peas and cowpea
		4. Beans
		5. Leafy vegetables

LEARNING OUTCOMES

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

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

THEORY

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

Unit I: *Tuber crops*: Potato

Unit II: *Fruit vegetables*- Tomato, eggplant, hot pepper, sweet pepper and okra Unit

III: *Leguminous vegetables*- Garden peas and cowpea

Unit IV: *Leguminous vegetables*: French bean, Indian bean, cluster bean and broad bean Unit

V: *Leafy vegetables*- Lettuce and fenugreek

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 METHODS/ACTIVITIES

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

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.
- 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.
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- Kaloo, 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 Kaloo, G. (Eds.), 1995, Vegetable research with special reference to hybrid technology in Asia-Pacific Region. FAO.
- Peter, K.V. and Pradeep kumar, 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
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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.
- 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.

VSC 506: BREEDING OF CROSS POLLINATED VEGETABLE CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

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

The course is constructed given as under:

S.No	Block	Unit
1.	Breeding of cross pollinated vegetable Crops	1. Cucurbitaceous crops
		2. Cole crops
		3. Root and bulb crops
		4. Tuber crops
		5. Leafy vegetables

LEARNING OUTCOMES

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

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

THEORY

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

Unit I: *Cucurbitaceous crops*- Gourds, melons, cucumber, pumpkin and squashes

Unit II: *Cole crops*- Cauliflower, cabbage, kohlrabi, broccoli and brussels sprouts

Unit III: *Root and bulb crops*- Carrot, radish, turnip, beet root and onion

Unit IV: *Tuber crops*- Potato, Sweet potato, tapioca, taro and yam

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 biotic and 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 METHODS/ACTIVITIES

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

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

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VSC 507: PROTECTED CULTIVATION OF VEGETABLE CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

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

The course is constructed given as under:

S.No	Block	Unit
1.	Protected cultivation of vegetable crops	1. Scope and importance
		2. Types of protected structure
		3. Abiotic factors
		4. Nursery raising
		5. Cultivation of crops
		6. Solutions to problems

LEARNING OUTCOMES

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

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

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. Climate control and automation in polyhouse.

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 lightStudy of different types of growing media, training and pruning systems ingreenhouse crops
3. Study of fertigation and nutrient management under protected structures
4. Study of insect pests and diseases in greenhouse and its control
5. Use of protected structures in hybrid seed production of vegetables
6. Economics of crops grown in protected cultivation
7. Visit to established green/polyhouses/shade net houses in the region

TEACHING METHODS/ACTIVITIES

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

RESOURCES

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

Chandra, S. and Som, V., 2000, Cultivating vegetables in green house. Indian horticulture. 45:17-18.

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

Parvatha, R. P., 2016, Sustainable crop protection under protected cultivation. E-BookSpringer.

Prasad, S. and Kumar, U., 2005, Greenhouse management for horticultural crops. 2ndEd.Agrobios.

Resh, H.M., 2012, Hydroponic food production. 7thEdn. CRC Press.

Singh, B., 2005, Protected cultivation of vegetable crops. Kalyani publishers, New Delhi

Singh, D.K. and Peter, K.V., 2014, Protected cultivation of horticultural crops (1st Edition) New India publishing agency, New Delhi.

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

Tiwari, G.N., 2003, Green house technology for controlled environment. Narosa publ. house.

VSC 508: SEED PRODUCTION OF VEGETABLE CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

To impart a comprehensive knowledge and skills on quality seed production of vegetable crops
The course is constructed given as under:

Block	Unit
Seed production of vegetable crops	1. Introduction, history, propagation and reproduction
	2. Agro-climate and methods of seed production
	3. Seed multiplication and its quality maintenance
	4. Seed harvesting, extraction and its processing
	5. Improved agro-techniques and field and seed standards

LEARNING OUTCOMES

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

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

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, tuber 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 METHODS/ACTIVITIES

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

RESOURCES

- Agarwal, P. K. and Anuradha, V., 2018, Fundamentals of seed science and technology. Brilliant publications, New Delhi.
- Agrawal, P.K. and Dadlani M. (Eds.), 1992, Techniques in seed science and technology. South asian Publ.
- Agrawal, R.L. (Ed.), 1997, Seed technology. Oxford and IBH.
- 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.
- Bendell, P.E. (Eds.), 1998, Seed science and technology: Indian forestry species. Allied Publ.
- 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 Choudhary, A.K., 2000, Vegetable crops: breeding and seed production. Vol. I. Kalyani Publ.
- George, R.A. T., 1999, Vegetable seed production (2nd Edition). CAB International.
- Hazra, P. and Som, H.G. 2015, Seed production and hybrid technology of vegetable crops. Kalyani publishers, Ludhiana.
- Kaloo, G., Jain, S.K., Vari, A.K. and Srivastava, U., 2006, Seed: A global perspective. Associated publishing company, New Delhi.
- Kumar, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops. Agro botanical publ.
- More, T.A., Kale, P.B. and Khule, B.W., 1996, Vegetable seed production technology. Maharashtra state seed corp.
- Rajan, S. and Markose, B. L., 2007, Propagation of horticultural crops. New India publ.agency.

Singh, N.P., Singh, D.K., Singh, Y.K. and Kumar, V., 2006, Vegetable seed production technology. International book distributing Co.

Singh, S.P., 2001, Seed production of commercial vegetables. Agrotech publ. academy.

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

VSC 509: PRODUCTION OF UNDERUTILIZED VEGETABLE CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

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

S.No	Block	Unit
1.	Production of underutilized Vegetable crops	1. Stem and bulb crops
		2. Cole and salad crops
		3. Gourds and melons
		4. Leafy vegetables
		5. Yams and beans

LEARNING OUTCOMES

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

- Appreciate the scope and scenario of production of underutilized vegetable crops in India
- Acquire knowledge about the production technology of underutilized vegetable crops
- Adopting production of lesser utilised crops as entrepreneur

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, celery, parsley and parsnip
Rhubarb, globe artichoke, sweet corn and babycorn

UNIT III: *Leafy vegetables*- Celery, parsley, Indian spinach (poi), spinach, chenopods, chekurmanis and indigenous vegetables of regional importance

UNIT IV: *Gourds and melons*- Sweet gourd, spine gourd, teasle gourd, round gourd, and little/Ivygourd, snake gourd, pointed gourd, kachri, long melon, snap melon, Ash gourd, summer squash, Stuffing cucumber, Chow chow/ Chayote and gherkin

UNIT V: *Yam and beans*- Elephant foot yam, yam, yam bean, lima bean, jack bean, velvet bean, rice bean, Tree bean, Agathi and winged bean

UNIT VI: Fruit vegetables- Cherry tomato, tree tomato

UNIT VII: Aquatic vegetables: water chestnut, Chinese water chestnut, Indian lotus, water cress, swamp taro and prickly water lily/ Makhana

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 METHODS/ACTIVITIES

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

RESOURCES

Bhat, K.L., 2001, Minor vegetables-untapped potential. Kalyani publishers, New Delhi.

Indira, P. and Peter, K.V., 1984, Unexploited tropical vegetables. Kerala agricultural university, Kerala.

Pandey, A.K., 2011, Aquatic vegetables. Agrotech publisher academy, New Delhi.

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

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 and III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.

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

Rubatzky, V.E. and Yamaguchi, M., 1997, World vegetables: vegetable crops. NBPGR, New Delhi.

VSC 510: SYSTEMATICS OF VEGETABLE CROPS (1+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

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

The course is constructed given as under:

S.No.	Block	Unit
1	Systematic of vegetable crops	1. Significance of systematics
		2. Origin and evolution
		3. Botanical and morphological description
		4. Cytology
		5. Molecular markers

LEARNING OUTCOMES

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

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

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 METHODS/ACTIVITIES

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

RESOURCES

- Chopra, G.L., 1968, Angiosperms- systematics and life cycle. S. NaginDutta, A.C., 1986, A class book of botany. Oxford Univ. Press.
- Pandey, B.P., 1999, Taxonomy of angiosperm. S. Chand and Co
- 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. Box722200, 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.
- Simmonds, N.W. and Smartt, J., 1995, Evolution of crop plants. Wiley-Blackwell.
- Soule, J., 1985, Glossary for Horticultural Crops. John Wiley and Sons.
- Srivastava, U., Mahajan, R.K., Gangopadyay, K.K., Singh, M. and Dhillon, B.S., 2001, Minimal descriptors of agri-horticultural crops. Part-II: Vegetable Crops. NBPGR, New Delhi.
- Vasistha, 1998, Taxonomy of angiosperm. KalyaniPubl.
- Vincent, E.R. and Yamaguchi, M., 1997, World vegetables. 2nd Ed. Chapman andHall.

VSC 511: ORGANIC VEGETABLE PRODUCTION (1+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

To elucidate principles, concepts and their applications in organic farming of vegetable crops The course is constructed given as under:

S.No.	Block	Unit
1	Organic vegetable production	1. Importance and principles
		2. Organic production of vegetables
		3. Managing soil fertility
		4. Composting methods
		5. Certification and export

LEARNING OUTCOMES

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

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

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 and crop diversification in organic production; Processing and quality control of organic vegetable produce

UNIT IV: *Composting methods*- Indigenous methods of composting, Panchyagavya, Biodynamics preparations and their application; ITKs in organic vegetable farming; concentrated organic manures, crop residues, agro industrial wastes; 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, vermicompost, biofertilizers and biopesticides
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. Seed enhancement and strategies for organic seed production in vegetables.
6. Visit to organic fields and marketing centres

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Dahama, A.K., 2005, Organic farming for sustainable agriculture.2nd Ed. Agrobios.

Gehlot, G., 2005, Organic farming; standards, accreditation certification and inspection. Agrobios.

Palaniappan, S.P. and Annadorai, K., 2003. Organic farming, theory and practice.Scientificpubl.

Pradeepkumar, T., Suma, B., Jyothibhaskar and Satheesan, K.N., 2008. Management of horticultural crops.New India Publ. Agency.

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

VSC 512: PRODUCTION OF SPICE CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

To impart basic knowledge about the importance and production technology of spices grown in India
The course is constructed given as under:

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

LEARNING OUTCOMES

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

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

THEORY

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

UNIT I: *Fruit spices*- Black pepper, small cardamom, large cardamom and allspice

UNIT II: *Bud and kernel*- Clove and nutmeg

UNIT III: *Underground spices*- Turmeric, ginger and garlic

UNIT IV: *Seed spices*- Coriander, fenugreek, cumin, fennel, ajowain, dill and celery

UNIT V: *Tree spices*- Cinnamon, tamarind, garcinia and vanilla

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 METHODS/ACTIVITIES

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

RESOURCES

- Agarwal, S., Sastry, E.V.D. and Sharma, R.K., 2001, Seed spices: production, quality, export. Pointer Publication.
- Arya, P.S., 2003, Spice crops of India. Kalyani.
- Bhattacharjee, S.K., 2000, Hand book of aromatic plants. Pointer publications.
- Bose, T.K., Mitra, S.K., Farooqi, S.K. and Sadhu, M.K. (Eds.), 1999, Tropical horticulture. Vol.I. Naya Prokash.
- Chadha, K.L. 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, N.A., Khader, P., Rangaswami and Irulappan, I., 2000, Introduction to spices, plantation crops, medicinal and aromatic plants. Oxford and IBH.
- Nybe, E.V., Miniraj, N. and Peter, K.V., 2007, Spices. New India Publ. Agency.
- Parthasarthy, V.A., Kandiannan, V. and Srinivasan, V., 2008, Organic spices. New India Publ. Agency.
- Peter, K.V., 2001, Hand book of herbs and spices. Vols. I-III. Woodhead Publ. Co. UK and CRC USA
- Pruthi, J.S. (Ed.), 1998, Spices and condiments. National Book Trust
- Pruthi, J.S., 2001, Minor spices and condiments- crop management and post harvest technology. ICAR.
- Purseglove, J.W., Brown, E.G., Green, C.L. and Robbins, S.R.J. (Eds.), 1981, Spices. Vols. I, II. Longman.
- Shanmugavelu, K.G., Kumar, N. and Peter, K.V., 2002, Production technology of spices and plantation crops. Agrobios.
- Thamburaj, S. and Singh, N. (Eds.), 2004, Vegetables, tuber crops and spices. ICAR.
- Tiwari, R.S. and Agarwal, A., 2004, Production technology of spices. International Book Distr. Co.
- Varmudy, V., 2001, Marketing of spices. Daya Publ. House.

VSC 513: PROCESSING OF VEGETABLE CROPS (1+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

To educate the students about the principles and practices of processing in vegetable crops The course is constructed given as under:

S.No.	Block	Unit
1	Processing of vegetable crops	1. Present status
		2. Spoilage and biochemical changes
		3. Processing equipments
		4. Quality control
		5. Value addition

LEARNING OUTCOMES

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

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

THEORY

UNIT I: *Present status*- Present status and future prospects of vegetable preservation industry in India

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

UNIT III: *Processing equipments*- Raw material for processing; Primary and minimal processing; Processing equipments; Layout and establishment of processing industry; FPO licence; Importance of hygiene; Plant sanitation

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

UNIT V: *Value addition*- Major value added vegetable products; Utilization of byproducts of vegetable processing industry; Management of processing industry waste; Investment analysis; Principles and

methods of sensory evaluation of fresh and processed vegetables

PRACTICAL

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

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Arthey, D. and Dennis, C., 1996, Vegetable processing. Blackie/Springer-Verlag.

Chadha, D.S., 2006, *The Prevention of food adulteration act*. Confed. of Indian Industry.

Desrosier, N.W., 1977, Elements and technology. AVI Publ. Co.

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

Frazier, W.C. and Westhoff, D.C., 1995, Food microbiology. 4th Ed. Tata Mc Graw Hill.

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VSC 514: POSTHARVEST MANAGEMENT OF VEGETABLE CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THE COURSE

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

The course is organized as follows:

S.No.	Blocks	Units
1	Post-harvest management of vegetable crops	1. Importance and scope
		2. Maturity indices and biochemistry
		3. Harvesting and losses factors
		4. Packinghouse operations
		5. Methods of storage

LEARNING OUTCOMES

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

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

THEORY

UNIT I: *Importance and scope*- Importance and scope of post-harvest management of vegetables

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

UNIT III: *Harvesting and losses factors*- Harvesting tools and practices for specific market requirement; Postharvest physical and biochemical changes; Preharvest practices and other factors affecting postharvest losses; post harvest handling of vegetables

UNIT IV: *Packinghouse operations*- Packing house operations; Commodity pretreatments chemicals, wax coating, precooling and irradiation; Packaging of vegetables, prevention from infestation, management of postharvest diseases and principles of transportation

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

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 METHODS/ACTIVITIES

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

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.

Mitra, S.K., 1997, Postharvest physiology and storage of tropical and sub-tropical fruits. CABI.

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.

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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.

Ph. D.Courses

VSC 601: RECENT TRENDS IN VEGETABLE PRODUCTION (3+0)

WHY THE COURSE?

India is the second largest producer of vegetables in the world, next only to China. Most challenging task is to ensure for continuous and enough supply of vegetables to growing population. Urban areas are experiencing substantial increase in population; this growth is accompanied with change in food habits and rising concerns for food quality. Here, food quality refers to the optimum levels of the nutrition in the food along with the minimized amount of the chemical (pesticides/fertilizers) residues used in the production of the vegetables. Vegetables are being highly seasonal, perishable are also capital and labour intensive and need care in handling and transportation. Environmental stress (climate change) and shortage of water and land resources are major constraints haunting the production. Though the advances in science and information technology has resulted in more comfortable world with global linkages, these advances has led to changes in production practices. Thus, the students of vegetable science need to have an understanding of recent trends in production technology of vegetable crops and their management.

AIM OF THE COURSE

To keep abreast with latest developments and trends in production technology of vegetable crops.

The course is constructed given as under:

S. No.	Block	Unit
1	Recent trends in vegetable production	1. Solanaceous crops
		2. Cole crops
		3. Okra, onion, peas and beans, amaranth and drumstick.
		4. Root crops and cucurbits
		5. Tuber crops

LEARNING OUTCOMES

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

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

THEORY

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

UNIT-I: *Solanaceous crops*: Tomato, brinjal, chilli, sweet pepper and potato.

UNIT-II: *Cole crops*: Cabbage, cauliflower and knol-khol, sprouting broccoli.

UNIT-III: Okra, onion, peas and beans, amaranth, spinach, palak and drumstick.

UNIT-IV: *Root crops and cucurbits*: Carrot, beet root, turnip and radish and cucurbits

UNIT-V: *Tuber crops*: Sweet potato, Cassava, elephant foot yam, Dioscorea and taro.

TEACHING METHODS/ACTIVITIES

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Group discussion

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.
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- 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.
- FFTC., Improved vegetable production in Asia. Book Series No. 36.
- Ghosh, S.P., Ramanujam, T., Jos, J.S., Moorthy, S.N. and Nair, R.G., 1988, Tuber crops. Oxford and IBH.
- Gopalakrishnan, T.R., 2007, Vegetable crops. New India Publ. Agency.
- Hazra, P. and Som, M.G., 2015, Seed production and hybrid technology of vegetable crops. Kalyani publishers, Ludhiana.
- Hazra, P., 2016, Vegetable science. 2ndedn, Kalyani publishers, Ludhiana.
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- Kaloo, 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.
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- 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.
- Sin, M.T. and Onwueme, I.C., 1978, The tropical tuber crops. John Wiley and Sons.
- 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.

VSC 602: ADVANCES IN BREEDING OF VEGETABLE CROPS (3 +0)

WHY THE COURSE?

The improvement of vegetable crops has until recently, been largely confined to conventional breeding approaches and such programmes rely on hybridization of plants which have desirable heritable characteristics and on naturally or artificially induced random mutations. The introduction of new genetic information can result in increased resistance to insect pest, diseases tolerance to environmental condition, improved quality *etc.* The modern biotechnological tools like molecular assisted selection, double haploidy, genetic engineering *etc.* can be of immense importance for rapid development of superior varieties with desirable qualitative and quantitative traits. Therefore, conventional breeding in conjunction with molecular biology has bright prospects of developing high yielding vegetable varieties with high nutraceuticals and bio active compounds suitable for fresh as well as processed market. The students of vegetable science who are having breeding as major subject need to have an understanding of recent technologies in vegetable crops.

AIM OF THE COURSE

To impart knowledge on the recent research trends and advances in breeding of vegetable crops.

The course is constructed given as under:

S.No.	Block	Unit
1	Advances in Breeding of vegetable crops	1. Solanaceous crops and okra
		2. Cucurbits and Cole crops
		3. Legumes and leafy vegetables
		4. Root crops and onion
		5. Tuber crops

LEARNING OUTCOMES

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

- Breeding objectives and trends
- Recent Advances in vegetable breeding

THEORY

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

UNIT-I: *Solanaceous crops* - Tomato, Brinjal, Hot Peeper, Sweet Pepper, Okra and Potato UNIT-II: Cucurbits and Cole crops

UNIT-III: *Legumes and leafy vegetables* - Peas and Beans, Amaranth, Palak, Chenopods and Lettuce.

UNIT-IV: *Root crops and onion* - Carrot, Beetroot, Radish, Turnip, Onion

UNIT-V: *Tuber crops* - Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea

TEACHING METHODS/ACTIVITIES

- Classroom Lectures
- Assignment (written and speaking)
- Student presentation
- Group discussion

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., Bosermark, 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
- Kaloo, G., 1988, Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA. Kaloo, G., 1988, Vegetable breeding. Vols. I-III. CRC Press.
- Kaloo, 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 Kaloo, 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 B.D. 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.

VSC 603: ABIOTIC STRESS MANAGEMENT IN VEGETABLE CROPS (2+1)

WHY THE COURSE?

Improvement of vegetable crops has traditionally focused on enhancing a plant's ability to resist diseases or insects. That is evidenced by the large number of disease- or insect- resistant cultivars or germplasm released and used. Research on crop resistance or tolerance to abiotic stresses (heat, cold, drought, flood, salt, pH, etc.) has not received much attention. However, that is changing as a result of the research and publicity of global warming. The changing environments pose serious and imminent threats to vegetable production and place unprecedented pressures on the sustainability of vegetable production. The challenges and opportunities coexist for our dynamic and resilient industry. In addition to conserving resources, we should mitigate abiotic stresses and adapt to the warming planet. The student of vegetable science need to know the different methods involved to mitigate the abiotic stress in vegetable crops.

AIM OF THE COURSE

To update knowledge on the recent research trends in the field of abiotic stress management in vegetables.

- To teach management practices to mitigate abiotic stress in vegetable crops

The course is constructed given as under:

S. No.	Block	Unit
1	Abiotic stress management in vegetable crops	1. Environmental stress
		2. Mechanism and measurements of tolerance
		3. Soil-plant-water relations
		4. Techniques of growing vegetables under high stress
		5. Use of chemicals

LEARNING OUTCOMES

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

- Acquire the knowledge about effect of different abiotic stresses on vegetables
- Methods to mitigate abiotic stress in vegetables

THEORY

Block 1: Abiotic stress management in vegetable crops

UNIT I: *Environmental stress* - its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress. Disaster mitigation- Floods, Hail storms, Heat wave

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.

TEACHING METHODS/ACTIVITIES

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

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 PressLLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
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- Rao, N.K. (Eds.), 2016, Abiotic stress physiology of horticultural crops. Springer publication.

VSC 604: SEED CERTIFICATION, PROCESSING AND STORAGE OF VEGETABLE SEEDS (2+1)

WHY THE COURSE?

Every farmer should be able to access healthy seeds which are genetically pure, with high seed vigour and good germination percentage. Timely availability of good quality seeds at reasonable price ensures good yield and profit to the farmers. The seeds play a vital role in agriculture and acts as a carrier of the genetic potential of varieties. Quality seed production which follows efficient certification procedures plays a major role in the increase of food production of our country. To ensure this, the Government has prescribed standards and has brought in seed production techniques, testing, certification and marketing procedures through the Seeds Act, 1966. In the current scenario, the demand for good quality certified seeds far exceeds the availability in the market. This manual provides details about production and procurement of good quality seeds.

AIM OF THE COURSE

To impart the knowledge on seed certification, processing and storage of vegetable seeds

Learning outcomes

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

- Acquire the knowledge on seed certification
- Acquire the knowledge on seed processing and storage

THEORY

Block 1: Seed Certification, Processing and Storage of Vegetable Seeds.

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 METHODS/ACTIVITIES

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

➤ Group discussion

RESOURCES

Agarwal, 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

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Kaloo, G., Jain, S.K., Vari, A.K. and Srivastava, U., 2006, Seed: A global perspective. Associated publishing company, New Delhi.

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

VSC 605: BREEDING FOR SPECIAL TRAITS IN VEGETABLE CROPS (2+0)

WHY THE COURSE?

Many epidemiological studies reveal that people having a high level of consumption of vegetables presents a better health and lower risk of chronic diseases, including cardiovascular diseases and different types of cancer. Vegetables contain many bioactive compounds and represent a major source of antioxidants and other compounds that are beneficial to human health. Consumers are increasingly demanding vegetables with bioactive properties that contribute to maintaining a good health and preventing diseases. In consequence, breeding programmes in vegetables are increasingly considering the content in bioactive compounds as a major breeding objective. In this way, there is an increasing number of breeding programmes and scientific studies aimed at improving the content in bioactive compounds of vegetables, and the trend seems that will continue in the coming years. In this respect, the particular course has been designed for students of Vegetable Science department.

AIM OF THE COURSE

To impart knowledge on recent developments in breeding for improved nutritional quality in important vegetable crops

LEARNING OUTCOMES

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

- Know about various special characters of vegetables
- The recent breeding methods to achieve special characters in vegetables

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; Abiotic stress

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: Biofortification in vegetable crops, genetic engineering for improvement of quality traits in vegetable crops, bioavailability of dietary nutrients from improved vegetable crops and impact on micronutrient malnutrition, achievements and future prospects in breeding for quality traits in vegetables.

TEACHING METHODS/ACTIVITIES

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

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.

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

Kaloo, G., 1988, Vegetable breeding. Vols. I-III. CRC Press.

Kaloo, 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 Kaloo, 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.

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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.

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

VSC 606: BIODIVERSITY AND CONSERVATION OF VEGETABLE CROPS (2+1)

WHY THIS COURSE?

The availability of pertinent gene pool is of utmost importance to mitigate adverse climate and to counter diseases and pests. In addition, specific gene sources (germplasm) would always be necessary to develop superior genotypes. Considering the importance of conserving biodiversity in vegetable crops for future use, the course has been designed.

AIM OF THIS COURSE

To understand the status and magnitude of biodiversity and strategies in germplasm conservation of vegetable crops.

The course is organised as follows :-

S. No.	Blocks	Units
1	Biodiversity and conservation of vegetable crops	1. General Aspects : Issues, Goals and Current Status
		2. Germplasm Conservation : Collection, Maintenance and Characterization
		3. Regulatory Horticulture : Germplasm Exchange, Quarantine and Intellectual Property Rights

LEARNING OUTCOMES

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

THEORY

UNIT I: *General aspects : issues, goals and current status*: Biodiversity and conservation; issues and goals- needs and challenges ; present status of gene centres; Genetic resources; world's major centres of fruit crop domestication; current status of germplasm availability/database of fruit crops in India; threatened sp

UNIT II: *Germplasm conservation: collection, maintenance and characterization*: Principles and methods of 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 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 fruit and nut germplasm, plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. Biodiversity Act, 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.

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 standardised DUS test protocol
8. Special tests with biochemical and molecular markers

TEACHING METHODS / ACTIVITIES

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

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.

Peter, K.V., 2008, Biodiversity of horticultural crops. Vol. II. Daya Publ. House, Delhi.

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 and exotic). 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

VSC 607: BIOTECHNOLOGICAL APPROACHES IN VEGETABLE CROPS (2+1)

WHY THE COURSE?

Biotechnology is a rapidly developing area of contemporary science. It can bring new ideas, improved tools and novel approaches to the solution of some persistent, seemingly intractable problems in vegetable production. Given the pressing need to enhance and stabilize the vegetable production in response to mounting population pressures and increasing awareness, there is an urgent need to explore novel technologies that will break traditional barriers.

AIM OF THIS COURSE

To impart latest knowledge in biotechnical advancement in vegetable crops The course is organised as follows :-

S. No.	Blocks	Units
1	Bio technological approaches in vegetable crops	1. Importance and scope of Biotechnology
		2. Somatic embryogenesis
		3. Blotting techniques, DNA finger printing,
		4. Plant genetic engineering
		5. Concepts and methods of next generation sequencing(NGS)

LEARNING OUTCOMES

The student would be expected to learn

- Different biotechnological tools
- NGS, genetic engineering

THEORY

Block 1: Biotechnological approaches in vegetable crops

UNIT I: *Importance and scope of biotechnology* - in vegetable crop improvement. *In vitro* culture, micropropagation, anther culture, pollen culture, ovule culture, embryo culture, endosperm culture.

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), Speed Breeding

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

PRACTICALS

1. Micropropagation, Pollen- Ovule and Embryo culture- Synthetic seed production (2)
2. *In vitro* mutation induction, *in vitro* rooting – hardening at primary and secondary nurseries (3).
3. DNA isolation from economic vegetable crop varieties – Quantification and amplification (2) DNA

- and Protein profiling – molecular markers, PCR Handling (2)
4. Vectors for cloning and particle bombardment (3)
 5. DNA fingerprinting of flower crop varieties (3)
 6. Project preparation for establishment of low, medium and high cost tissue culture laboratories (1)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Bajaj, Y.P.S. (Ed.), 1987, Biotechnology in agriculture and forestry. Vol. XIX. Hitech and Micropropagation. 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.
- Gorden, H. and Rubsell, S., 1960, Hormones and cell culture. AB Book Publ.
- 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 genettransfer. Orient and Longman, USA.
- Keshavachandran, R., 2007, Recent trends in biotechnology of horticultural crops. New - India publication agency, New Delhi.
- Panopoulos, N.J. (Ed.), 1981, Genetic engineering in plant sciences. Praeger Publ.
- 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.
- Pierik, R.L.M., 1987, In vitro culture of higher plants. Martinus Nijhoff Publ.
- Prasad, S., 1999, Impact of plant biotechnology on horticulture. 2nd Ed. Agro Botanica.
- Rout, G.R. and Peter, K.V., 2018, Genetic engineering of horticultural crops. Academic press Elsveer, USA.
- 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.

VSC 608: ADVANCED LABORATORY TECHNIQUES FOR VEGETABLE CROPS(1+2)

WHY THE COURSE?

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

AIM OF THIS COURSE

To familiarize with the laboratory techniques for analysis of vegetable crops. The organisation of the course is as under :-

S. No.	Blocks	Units
1	Advanced laboratory techniques for vegetable crops	1. Safety measures and laboratory maintenance
		2. Qualitative and quantitative analysis destructive and non-destructive analysis methods
		3. Chromatographic and microscopic analysis
		4. Sensory analysis

LEARNING OUTCOMES

The students would be expected to develop skills and expertise on

- Upkeep of laboratories and handling of research instruments
- Principles and methods of various analysis

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 watercontent (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 food 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 horticultural produce.

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 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 METHODS / ACTIVITIES

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

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.

SUGGESTED JOURNALS

S. 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 of 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	Journal of arecanut and spice crops	
18	Journal of foodscience 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
27	Vegetable Science	2455-7552

FLORICULTURE AND LANDSCAPING (FLS)

M. Sc. (Hort.) Floriculture and Landscaping

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

* Compulsory among major courses

Ph. D. (Hort.) Floriculture and Landscaping

Code	Course	Credit hours
Major Courses(12 Credits)		
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		100

* Compulsory among major courses

M.Sc. Syllabus

FLS 501: SYSTEMATICS OF ORNAMENTAL PLANTS (1+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

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

The course is organized as follows

S.No.	Blocks	Units
1	Nomenclature	Unit 1: History, origin, hotspots, classification and nomenclature systems Unit 2: International Code, Identification features, descriptors. Unit 3: Red Book, Registration with NBPGR, PPVFRA
2	Families	Unit 1: Rosaceae, Asteraceae, Caryophyllaceae, Orchidaceae, Aracaceae, Liliaceae, Unit 2: Acanthaceae, Palmaceae, Asparagaceae, Malvaceae, Musaceae, Oleaceae, Iridaceae.
3	Molecular techniques	Unit 1: Molecular techniques in modern systematics.

LEARNING OUTCOME

After successful completion of this course,

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

THEORY

Block I: Nomenclature

UNIT I: Nomenclature: History, origin, hotspots, classification and nomenclature systems

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

UNIT III: Red Book, Registration (NBPGR, PPVFRA, NBA)

Block 2: Families

UNIT I: Families: Description and families and important genera Rosaceae, Asteraceae, Caryophyllaceae, Orchidaceae, Aracaceae, Liliaceae,

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

Block 3: Molecular techniques

UNIT I: Molecular techniques in modern systematics

PRACTICALS (16)

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

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Bhattacharya, B. & Johri, B.M. 2004. *Flowering Plants: Taxonomy and Phylogeny*. Narosa Publ. House, New Delhi, India. pp.753.
- Dutta, A.C. 1986. *A Class Book of Botany*. Oxford Univ. Press, Kolkata, India.
- Pandey, B.P. 2013. *Taxonomy of Angiosperms*. S. Chand & Co. pp. 608.
- Rajput, C.B.S. & Haribabu, R.S. 2014. *Citriculture*, Kalyani Publ., New Delhi, India.
- Spencer, R.R., Cross, R. & Lumley, P. 2007. *Plant Names*. 3rd Ed. *A Guide to Botanical Nomenclature*. CSIRO Publ., Australia., 176 p.
- Vasistha, B.B. 1998. *Taxonomy of Angiosperms*. Kalyani Publ., New Delhi, India.

FLS 502: BREEDING OF ORNAMENTAL CROPS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

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

The course is organized as follows

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

LEARNING OUTCOME

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

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

THEORY

Block 1: Principles of Plant Breeding

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

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

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

Block 2: Breeding methods

UNIT I: Breeding methods: Breeding methods suitable for sexually, asexually propagated flower crops, self and cross pollinated crops- pedigree selection, backcross, clonal selection, polyploidy and mutation breeding, heterosis and F1 hybrids.

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

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

PRACTICALS

1. Floral biology of important ornamental crops (2)
2. Cytology and cytogenetics (2)
3. Selfing and crossing procedures for important ornamental crops (2)
4. Evaluation of hybrid progenies (2)
5. Induction of mutants through physical and chemical mutagens (2)
6. In vitro selection, genetic engineering (2)
7. Induction of polyploidy (2)
8. DUS testing (2)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Vainstein, A. (Ed). 2002. *Breeding for ornamental crops: Classical and Molecular Approaches*. Springer-Science-Business Media, B.V. Edition 1. pp. 392.
- Bhattacharjee, S.K. 2018. *Advances in Ornamental Horticulture*. Pointer Publ., Reprint, 6vols, pp. 2065.
- Bose, T.K. & Yadav, L.P. 1989. *Commercial flowers*. Naya Prokash, Kolkata, India.
- Callaway, D. J. & Callaway, M. B. 2009. *Breeding Ornamental Plants*. Timber Press. Revised edition, pp. 359.
- Chadha, K. L. & 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, K. L. & Choudhury, B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
- Chaudhary, R.C. 1993. *Introduction to Plant Breeding*. Oxford & IBH Publ.
- Misra, R.L. & Misra, S. 2017. *Commercial Ornamental Crops: Cut Flowers*. Kruger Brentt Publisher UK Ltd. pp. 584.
- Misra, R.L. & Misra, S. 2017. *Commercial Ornamental Crops: Traditional and Loose Flowers*. Kruger Brentt Publisher UK Ltd.
- Singh, B. D. 2016. *Plant Breeding Principles and Methods*. Kalyani Publishers, New Delhi-Ludhiana, India.
- Watts, L. 1980. *Flower and Vegetable Plant Breeding*. Unilever Research, Sharnbrook, Bedford, UK. pp 182. Grower Books, London, UK.

FLS 503: COMMERCIAL PRODUCTION OF CUT FLOWERS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

To impart basic knowledge about the importance and production dynamics of cut flowers grown in India. The course is organized as follows

S.No	Blocks	Units
1	Production management	1. Scope and scenario
		2. Growing environment
		3. Crop Management
		4. Flower regulation
2	Postharvest Management and marketing	1. Post harvest management
		2. Marketing

LEARNING OUTCOMES

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

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

THEORY

Block 1: Production management

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

UNIT II: Growing environment: 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.

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

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

Block 2: Post harvest management and marketing

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

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

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

PRACTICALS (16)

1. Identification of varieties (1)
2. Propagation (2)
3. Microclimate management (2)
4. Training and pruning techniques (1)
5. Pinching, deshooking, disbudding, desuckering (1)
6. Practices in manuring, drip and fertigation, foliar nutrition, growth regulator application (2)
7. Harvesting techniques, post-harvest handling, cold chain (2)
8. Economics, Project preparation for regionally important cut flowers, crop specific guidelines for project financing (NHB guidelines) (2)
9. Visit to commercial cut flower units (2)
10. Case studies (1)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Arora, J.S. 2010. *Introductory Ornamental Horticulture*. Kalyani Publishers. 6th edition, pp. 230.
- Bhattacharjee, S. K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
- Bose, T. K., Maiti, R. G., Dhua, R. S. & Das, P. 1999. *Floriculture and Landscaping*. Prokash, Kolkata, India.
- Bose, T. K. & Yadav, L.P. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.
- Chadha, K. L. & 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, K. L. & Chaudhury, B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
- Dole, J. M. & Wilkins, H. F. 2004. *Floriculture-Principles and Species*. Prentice Hall. 2nd edition, pp. 1048.
- Larson, R. A. 1980. *Introduction to Floriculture*. New York Academic Press. pp. 628.
- Laurie, A. & Rees V, H. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publications, Jodhpur. pp.534.
- Prasad, S. & Kumar, U. 2003. *Commercial Floriculture*. Agrobios Publications, Jodhpur.
- Randhawa, G. S. & Mukhopadhyay, A. 2001. *Floriculture in India*. Allied Publ. pp 660.
- Reddy S, Janakiram T, Balaji , Kulkarni S. & Misra RL. 2007. *Hi- Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi, India.
- Singh, A. K. 2006. *Flower Crops: Cultivation and Management*. New India Publ. Agency, New Delhi, India. pp. 475.

FLS 504: COMMERCIAL PRODUCTION OF LOOSE FLOWERS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

To impart basic knowledge about the importance and management of loose flowers grown in India. The course is organized as follows

S.No	Blocks	Units
1	Production management	1. Scope and scenario
		2. Growing environment
		3. Crop management
		4. Flower regulation
2	Post harvest management and marketing	1. Post harvest management
		2. Marketing

LEARNING OUTCOMES

After successful completion of this course, the students would have

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

THEORY

Block 1: Production management

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

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

UNIT III: Crop management: 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.

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

Block 2: Post harvest management and marketing

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

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

Crops: Rose, jasmine, chrysanthemum, marigold, tuberose, China aster, crossandra, gaillardia, spider lily, hibiscus, Nerium, barleria, celosia, gomphrena, Madar (*Calotropis gigantea*), nyctanthes (Harsingar), Ervatamia (Chandni), ixora, lotus, water lily, Michelia (Champa), gardenia, Ixora and balsam.

PRACTICALS (16)

1. Identification of species and varieties (1)
2. Propagation and nursery management (1)

3. Training and pruning techniques (1)
4. Fertigation, foliar nutrition, growth regulator application (2)
5. Crop protection (2)
6. Pinching, disbudding, staking, harvesting techniques (1)
7. Post-harvest handling, storage and cold chain (2)
8. Project preparation for regionally important commercial loose flowers. crop specific guidelines for project financing (NHB guidelines) (2)
9. Cost Economics (2)
10. Exposure Visits to fields (2)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Arora, J. S. 2010. *Introductory Ornamental Horticulture*. Kalyani Publi. 6th Edition, pp. 230. Bhattacharjee, S. K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
- Bose, T. K. Maiti, R.G., Dhua, R.S. & Das, P. 1999. *Floriculture and landscaping*. Naya Prokash, Kolkata, India.
- Bose, T. K. & Yadav, L. P. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India.
- Chadha, K. L. & 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, K. L. & Chaudhury, B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
- Laurie, A. & Rees, V. H. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur. pp.534.
- Prasad, S. & Kumar, U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur. Randhawa, G. S. & Mukhopadhyay, A. 2001. *Floriculture in India*. Allied Publ. pp 660.
- Sheela, V. L. 2008. *Flowers for Trade*. Horticulture Science Series, vol.10, pp. 392. New India Publ. Agency, New Delhi, India.

FLS 505: ORNAMENTAL GARDENING AND LANDSCAPING (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

Familiarization with principles and practices of landscaping. The course is organized as follows

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

LEARNING OUTCOMES

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

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

THEORY

Block 1: Gardens and components

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

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

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

Block 2: Landscape planning

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

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

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

PRACTICALS (16)

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

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Bose, T. K., Chowdhury, B. & Sharma, S. P. 2011. *Tropical Garden Plants in Colour*. Hort. and Allied Publ.

Bose, T. K., Maiti, R.G., Dhua, R.S. & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.

Grewal, H. S. & Singh, P. 2014. *Landscape Designing and Ornamental Plants*. Kalyani Publ.

Lauria, A. & Victor, H.R. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur.

Misra, R. L. & Misra, S. 2012. *Landscape Gardening*. Westville Publ. House, New Delhi, India.

Nambisan, K.M.P. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH Publ. Co., New Delhi, India.

Randhawa, G.S. & Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publ.

Sabina, G.T. & Peter, K.V. 2008. *Ornamental Plants for Gardens*. New India Publ. Agency, New Delhi

Singh, A. & Dhaduk, B. K. 2015. *A Colour Handbook: Landscape Gardening*. New India Publ. Agency, New Delhi, India.

Valsalakumari, P. K., Rajeevan, P. K., Sudhadevi, P. K. & Geetha C.K. 2008. *Flowering Trees*. New India Publ. Agency, New Delhi, India.

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

FLS 506: INDOOR PLANTS AND INTERIORSCAPING (1+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE:

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

The course is organized as follows

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

LEARNING OUTCOMES

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

- Deep understanding and knowledge of principles affecting indoor cultivation including vertical gardens
- Develop required skills in interiorscaping
- Develop required entrepreneurial acumen

THEORY

Block 1: Scope, principles and operations

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

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

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

Block 2: Presentations and marketing

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

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

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

PRACTICALS (16)

1. Identification of important house plants (2)

2. Media and containers (1)
3. Propagation (1)
4. Cultural operations, maintenance and economics of indoor plants (2)
5. Models for Interiorscaping (2)
6. Familiarization with different indoor gardens (2)
7. Making of terrariums, bottle garden, dish garden and their economics (2).
8. Making of vertical gardens and economics (2)
9. Exposure visits (2)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Barbara, P. (2005). *The Complete Houseplant Survival Manual*. Storey Publ., New Adams.

Randhawa, G.S. & Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publ.

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

FLS 507: NURSERY MANAGEMENT IN ORNAMENTAL PLANTS (2+1)

WHY THIS COURSE?

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

AIM OF THIS COURSE

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

The course is organized as follows

S.No	Blocks	Units
1	Nursery Industry and Propagation	1. Scenario of nursery industry and sexual propagation
		2. Asexual propagation
		3. Micropropagation
2	Nursery Management	1. Growing structures
		2. Sanitary and phytosanitary issues
		3. Standards

LEARNING OUTCOMES

After successful completion of this course,

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

THEORY

Block 1: Nursery Industry and Propagation

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

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

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

Block 2: Nursery Management

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

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

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

PRACTICALS (16)

1. Anatomical studies in rooting of cutting and graft union (2)
2. Identification and production of plug plants, seedlings and saplings (2).
3. Preparation of growing media and use of PGRs (2).
4. Practice of propagation through specialized structures cuttings, layering, budding andgrafting (2)
5. Case studies (2).
6. Micropropagation of ornamental crops and hardening (3).
7. Visit to tissue culture labs and nurseries (2)
8. Economics (1)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Adriance, G.W. & Brison, F. R. 2000. *Propagation of Horticultural Plants*. Biotech Books, New Delhi, India.
- Bose, T. K., Mitra, S. K. & Sadhu, M. K. 1991. *Propagation of Tropical and Subtropical Horticultural Crops*. Naya Prokash, Kolkata, India.
- Chadha, K. L., Ravindran, P. L. & Leela Sahijram. 2000. *Biotechnology in Horticulture and Plantation Crops*. Malhotra Publ. House, New Delhi, India.
- Davies, Fred T. Jr., Geneve, R. L., Wilson, S. B., Hartmann, H. T. & Kester, D. L. 2018. *Hartmann and Kester's Plant Propagation: Principles and Practices*. Pearson Publ.9th Edition.
- Peter, K.V. 2008. *Basics of Horticulture*. New India Publ. Agency, New Delhi, India.
- Rajan, S. & Baby, L.M. 2007. *Propagation of Horticultural Crops*. New India Publ. Agency, New Delhi, India. pp. 251.
- Singh, S.P. 1989. *Mist Propagation*. Metropolitan Book Co., New Delhi, India.

WHY THIS COURSE?

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

AIM OF THIS COURSE

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

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

LEARNING OUTCOMES

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

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

THEORY

Block 1: Turf industry and turf grasses

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

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

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

Block 2: Turf for different grounds

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

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

PRACTICALS (16)

1. Identification of turf grasses and turf machinery (1)
2. Soil preparation, turf establishment methods, provision of drainage (2)
3. Layout of macro and micro irrigation systems (1)
4. Water and nutrient management (2)
5. Special practices – mowing, raking, rolling, soil top dressing, weed management (2)
6. Biotic and abiotic stress management (2)

7. Project preparation for turf establishment (2)
8. Visit to parks, model cricket grounds and golf courses, airports, corporates, Govt.organizations (2)
9. Rejuvenation of lawns (1)
10. Turf economics (1)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Aldous, D.1999. *International Turf Management Handbook*. CRC Press. pp.368.
- Beard, J. B. 1972. *Turf Grass Science and Culture*. Pearson. 1st edition, pp. 672.
- Chawla, S. L., Patil, S., Patel, M. A., Patel, R. B. & Patel, R. M. 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, A.J.1980. *Turf grass Management*. Reston Publ. Inc.

WHY THIS COURSE?

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

AIM OF THIS COURSE

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

S.No	Blocks	Units
1	Value added products	1. Scope and scenario
		2. Value addition of loose flowers
		3. Floral Arrangements
		4. Dry flowers
2	Extraction of value added products	1. Essential oils
		2. Pigments and nutraceuticals

LEARNING OUTCOMES

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

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

THEORY

Block 1: Value added products

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

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

UNIT III: Floral Arrangements: Selection of containers and accessories for floral products and decorations. Flower arrangement, styles, Ikebana schools (*ikenobo*, *ohara*, *sogetsu* etc), Ikebana- moribana, nagiere, contemporary style.

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

Block 2: Extraction of value added products

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

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

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

PRACTICALS (16)

1. Practices in preparation of different type of flower arrangements including bouquets, button-

- holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers (4)
2. Techniques in flower arrangement and floral decoration (2)
3. Identification of plants for dry flower making (2)
4. Practices in dry flower making; Preparation of dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths, etc. (2)
5. Essential oil extraction units (1)
6. Extraction of pigments (2)
7. Visit to dry flower units (2)
8. Economics of value added products (1)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Bhattacharjee, S. K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.

Chadha, K. L. & Bhattacharjee, S.K. 1995. *Advances in Horticulture: Ornamental Plants*. Vol. XII, Parts 1 & 2. pp.533 & pp.574. Malhotra Publ. House, New Delhi, India.

Lauria, A. & Victor, H.R. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur.

Nowak, J. & Rudnicki, R. M. 1990. *Postharvest handling and storage of cut flowers, floristgreens, and potted plants*. Timber Press, USA. pp. 210.

Prasad, S. & Kumar, U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur.

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

WHY THIS COURSE?

Protected cultivation is more rewarding in production of high value cut flowers. With appropriate structures and plant environment control measures, the constraints of environment prevalent in the region can be overcome allowing almost year-round cultivation. The students need a thorough understanding of principles, types, designs, crops for different environments and management of environment in protected cultivation.

AIM OF THIS COURSE:

Understanding the principles, theoretical aspects and developing skills in protected cultivation of flower crops.

The course is organized as follows

S.No	Blocks	Units
1	Principles and types	1. Prospects and types of protected structures
		2. Principles and designs
2	Growing Environment	1. Control of environment
		2. Crop management and crop regulation
		3. Automation and standards

LEARNING OUTCOMES

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

- Knowledge on types, design and principles of protected structures
- Thorough understanding of principles of microclimate management and crop management.
- Develop the required skills for designing a greenhouse
- Acquire skills on microclimate management, production management

THEORY

Block 1: Principles and types

UNIT I: Prospects and types of protected structures: Prospects of protected floriculture in India; Types of protected structures – Glasshouse/polyhouse, shadenet houses, mist chambers, lath houses, orchidarium, fernery, rain shelters etc., ,

UNIT II: Principles and design: Principles of designing and erection of protected structures; Low cost/Medium cost/High cost structures; Location specific designs; Structural components; Suitable flower and foliage plants for protected cultivation.

Block 2: Growing environment

UNIT I: Control of environment: Microclimate management and manipulation of temperature, light, humidity, air and CO₂; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation, water harvesting.

UNIT II: Intercultural operations and crop regulation: Containers and substrates, media, soil decontamination, layout of drip and fertigation system, water and nutrient management, IPM and IDM, Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation.

UNIT III: Automation and standards: Automation in greenhouses, sensors, solar greenhouses and retractable greenhouses, GAP/Flower labels, Export standards, EXIM policy, APEDA regulations for export, Non-tariff barriers.

Crops: Rose, Chrysanthemum, Carnation, Gerbera, Orchids, Anthuriums, Lilium, Limonium, Lisianthus,

heliconia, Cala lily, Alstromeria, etc.,

PRACTICALS (16)

1. Study of various protected structures (1)
2. Design, layout and erection of different types of structures (2)
3. Practices in preparatory operations, growing media, soil decontamination techniques(2).
4. Microclimate management (2)
5. Practices in drip and fertigation techniques, special horticultural practices (2).
6. Determination of harvest indices and harvesting methods (1)
7. Postharvest handling, packing methods (1)
8. Economics of cultivation, Project preparation (2)
9. Project Financing guidelines (1)
10. Visit to commercial greenhouses (2)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Bhattacharjee, S. K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.

Bose, T.K., Maiti, R.G., Dhua, R.S. & Das, P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.

Bose, T. K. & Yadav, L. P. 1989. *Commercial Flowers*. Naya Prokash, Kolkata, India. Chadha, K. L. & Bhattacharjee, S.K. 1995. *Advances in Horticulture: Ornamental Plants*. Vol. XII, Parts 1 & 2. pp.533 & pp.574. Malhotra Publ. House, New Delhi, India.

Lauria, A. & Victor, H.R. 2001. *Floriculture-Fundamentals and Practices*. Agrobios Publ., Jodhpur.

Nelson PV. 2011. *Green House Operation and Management*. Pearson Publ. 7th edition, pp.624.

Prasad, S. & Kumar, U. 2003. *Commercial Floriculture*. Agrobios Publ., Jodhpur.

Randhawa, G.S. & Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publ.

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

FLS 511: CAD FOR LANDSCAPING (1+2)

WHY THIS COURSE?

CAD is widely used in landscaping planning and design. The students need to develop in depth knowledge of CAD software so that they can modify raw data into plans, drawing and models for landscape planning.

AIM OF THIS COURSE

To impart basic knowledge about the Computer Aided Designing (CAD) of landscape. The course is organized as follows

S.No	Blocks	Units
1	CAD	1. CAD basics and applications
		2. 2D drawing
2	ARCHICAD	1. 3D drawing
		2. Dimensioning and visualization

LEARNING OUTCOMES

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

- The students will be able to use CAD and ARCHICAD for landscape planning and designing.
- Develop the adequate skills to create 3 D model to showcase interaction of different factors in landscape gardening.
- Develop the entrepreneurial acumen

THEORY

Block 1: CAD

UNIT II: CAD basics and applications: Principles of integrating the architecture and landscaping, Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, Creating legends for plant and non- plant components, Basics of Photoshop software in garden designing.

UNIT II: 2D drawing: 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects. Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking, Script making, Using productivity tools, e-transmit file, making sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout.

Block 2: ARCHICAD

UNIT I: 3D drawing: 3D drawing methods, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD.

UNIT II: Dimensioning and visualization: ARCHICAD organization tools, Dimensioning and detailing of designs, Landscape designing softwares and CD ROM for ornamental plant material (TRES, HIMFLORA, CAPSSA, etc), Attribute settings of components, Visualization tools for landscape preview, Data management, plotting and accessories for designing, Inserting picture using photoshop, Making sample drawing for outdoor and indoor gardens.

PRACTICALS (32)

1. Practices in point picking methods, Using tool bars and icons, Using modifying tools and modifying comments (4).
2. Isometric drawings, Using productivity tools (2).

3. Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden (4).
4. Using tools and info-box for 3D drawing, Creation of garden components with ARCHICAD (4).
5. Organization, dimensioning, detailing and visualization tools with ARCHICAD (4)
6. Using Photoshop package for 3D picture insertion (2)
7. Drawing designs with ARCHICAD for home garden, interior garden designing, IT parks, Corporates, Theme parks and Ecotourism spots (6).
8. Exposure visits (4)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Christine, Wein-Ping Yu. 1987. *Computer-aided Design: Application to Conceptual Thinking in Landscape Architecture*. amazon.com.

Misra, R. L. & Misra, S. 2012. *Landscape Gardening*. Westville Publ. House, New Delhi, India.

FLS: 512-SEED PRODUCTION IN FLOWER CROPS (1+1)

WHY THIS COURSE

Seed production of flowers is a highly remunerative enterprise. The students need to have knowledge of seed industry, seed production methods and seed certification. This course provides hands on training on seed production of important flower crops.

AIM OF THIS COURSE

To impart basic knowledge about the importance of seed production in important flowercrops.

The course is organized as follows:

S.No	Blocks	Units
1	Seed Industry	1. Scenario of Seed industry
2	Hybrid Seed Production	1. Seed Production methods 2. Population improvement 3. F1 Hybrid production
3	Regulations	1. Seed certification and standards

LEARNING OUTCOMES

After successful completion of this course,

- The students will get a thorough knowledge on seed industry, principles and methods of seed production in flower crops.
- Students will get awareness on seed standards, certification and law in flower crops.

THEORY

Block 1

UNIT I: Scenario of Seed Industry: Scope, scenario and importance of seed production in flower crops. Constraints in flower seed production. Marketing and economics of flower seeds.

Block 2

UNIT I: Seed production-Methods: Methods of seed production, agrotechniques for production of nucleus, breeder and certified seeds. Harvesting, seed processing, seed priming, seed chain, packaging and storage.

UNIT II: Population improvement: Mass selection, progeny selection. Use of incompatibility and male sterility, maintenance of variety and seed production in flower crops.

UNIT III: F1 hybrids: F1 hybrid seed production advantages, steps involved in hybrid seed production, pollination behaviour and isolation, pollination management methods in production of F1/ hybrids in different flower crops

Block 3: Regulations

UNIT I: Seed certification and standards: Seed certification, Seed standards, seed act, plant breeders rights and farmers' rights, Bio safety, handling of transgenic seed crops, importing of seeds and OGL, trade barriers in seed business, sanitary and phytosanitary issues, custom clearance and quarantine.

Crops: Marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum, poppy, corn flower, rice flower, gaillardia, China aster, crossandra

PRACTICALS (16)

1. Seed production of open pollinated varieties (2)
2. Seed production of cross pollinated varieties (2)

3. Steps involved in hybrid seed production (2)
4. Hybrid seed production in different flower crops like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum etc. (6)
5. Visit to seed industry (3)
6. Visit to quarantine facility (1)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Bhattacharjee, S. K. 2018. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.

Bose, T.K., Yadav, L.P., Pal, P., Parthasarathy, V.A. & Das, P. 2003. *Commercial Flowers*. Vol. I & II. Naya Udyog, Kolkata, India.

Davies, Fred T. Jr., Geneve R. L., Wilson S. B., Hartmann, H. T., Kester, D. L. 2018. *Hartmann and Kester's Plant Propagation : Principles and Practices*. Pearson Publ. 9th Edition.

Larson, R.A. & Armitage A. M. 1992. *Introduction of Floriculture*. International Book Distributing Co., Lucknow, India.

Ph. D. Syllabus

FLS 601: CROP REGULATION IN ORNAMENTAL CROPS (2+1)

WHY THIS COURSE?

The course deals with the physiological and biochemical basis of crop regulation and programmed production of flower crops. The students need a thorough understanding on crop regulation to improve the profitability of growers.

AIM OF THIS COURSE:

Appraise on advances in programmed production of flower crops The course is organized as follows

S.No	Blocks	Units
1	Basis of crop regulation	1. Basis of flowering
		2. Growth regulators
2	Programming	1. Growth regulation
		2. Programmed production

LEARNING OUTCOMES

After successful completion of this course,

- The students will be abreast with physiological and biochemical basis of crop regulation in flower crops.
- The students will be able to carry out programmed production of flower crops.
- Instill the entrepreneurial acumen in the students

THEORY

Block 1: Basis of crop regulation

UNIT I: Basis of flowering: Ecophysiological influences on growth and development of flower crops for flowering, Crop load and assimilate partitioning and distribution. Root and canopy regulation,

UNIT II: Growth regulators: Study of plant growth regulators including biostimulants and polyamines in floriculture- structure, biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants. Absorption, translocation and degradation of phytohormones – internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition, Plant architecture management for flower crops and ornamental plants, molecular approaches in crop growth regulation.

Block 2: Programming

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

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

PRACTICALS

1. Plant architecture studies in important flower crops (2)
2. Bioassay and isolation through chromatographic analysis for auxins, gibberellins, cytokinins, ABA (4)
3. Growth regulation during propagation, dormancy, flowering (2)
4. Photoperiod regulation in short day and long day crops (2)
5. Off season production in important crops (2)
6. Bulb forcing in bulbous ornamental crops (2)
7. Exposure visits (2)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Buchanan, B. Gruissam, W. & Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*. 2015. Wiley Blackwell Publ. 2nd Edition, pp. 1280.
- De Hertagh, A. & 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, D. E. 1994. *Plant Growth and Development: A Molecular Approach*. Academic Press. pp. 580.
- Leopold, A. C. & Kriedemann, P. E. 1985. *Plant Growth and Development*. McGraw-Hill, New York. 3rd Edition.
- Peter, K. V. 2008. *Basics of Horticulture*. New India Publ. Agency, New Delhi, India.
- Roberts, J., Downs, S. & Parker, P. 2002. *Plant Growth Development: In Plant*. Oxford University Press. pp. 221-274.
- Salisbury, F. B. & Ross, C.W. 1992. *Plant Physiology, Hormones and Plant Regulators: Auxins and Gibberellins*. Wadsworth Publ., Belmont. 4th Edition, pp. 357-381.

FLS 602: POSTHARVEST BIOLOGY OF FLORICULTURAL CROPS (2+1)

WHY THIS COURSE?

The course deals with physiological, biochemical basis of senescence of flowers and the treatments and packaging methods to mitigate these processes for improving post harvest life.

AIM OF THIS COURSE:

To facilitate deeper understanding of biochemistry and postharvest technology in flowers at molecular as well as applied level.

The course is organized as follows

S.No	Blocks	Units
1	Pre-harvest and postharvest Physiology and biochemistry	1. Pre harvest physiology
		2. Senescence
		3. Pigments and secondary metabolites
2	Storage and packaging	1. Treatments and storage
		2. Packaging
		3. Dried ornamental crops

LEARNING OUTCOMES

After successful completion of this course,

- The students will be abreast with physiological and biochemical basis of senescence in flower crops.
- The students would acquire the required skill sets of managing the storage and packaging methods to be followed in case of flowers.
- Prepare the students to explore the entrepreneurial options in post harvest management.

THEORY

Block 1: Preharvest and post harvest physiology and biochemistry

UNIT I: Pre harvest physiology: Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and other biochemical changes, respiration, transpiration in important flower crops.

UNIT II: Senescence: Physiology and biochemistry of flowering, enzymatic changes, Ethylene sensitivity, ethylene evolution and management, 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.

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

Block 2: Storage and packaging

UNIT I: Storage of flowers: Treatments prior to shipment, viz., precooling, pulsing, impregnation, chemicals, Irradiation, biocontrol agents and natural plant products. Methods of storage: ventilated, refrigerated, Modified atmosphere, Controlled atmosphere storage, cool chain management, physical injuries and disorders in important flower crops.

UNIT II: Packaging: 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,

UNIT III: 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.

UNIT IV: 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.

PRACTICALS

1. Improved packaging and storage of important flowers (2).
2. Physiological loss in weight of flowers, estimation of transpiration, respiration rate, ethylene release and study of vase life (2)
3. Extension in cut flower vase life using chemicals (1)
4. Estimation of quality characteristics in stored flowers (1).
5. Estimation of biochemical changes like enzymatic changes, lipids and electrolyte leakage (2)
6. Extraction of flower pigments – Chlorophyll, xanthophylls, carotenoids and anthocyanins (4)
7. Cold chain management - visit to cold storage, MA and CA storage units (2)
8. Project preparation (2)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Buchanan, B. Gruissem, W. & Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*.

2015. Wiley Blackwell Publ. 2nd edition, pp. 1280.

Dey, P. M. & Harborne, J.B. 1997. *Plant Biochemistry*. Academic Press. 2nd Edition.

Glover, M. D. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall Publ.

Goodwin, T. W. & Mercer, E. I. 2003. *Introduction to Plant Biochemistry*. CBS Publ.

FLS 603: SPECIALTY FLOWERS, FILLERS AND CUT GREENS (1+1)

WHY THIS COURSE?

This course deals with introduction to specialty flowers, cut greens and fillers, ways to cultivate them and their post harvest handling and storage. The students need to be aware of these crops so that they could improve the profitability of growers.

AIM OF THIS COURSE:

To impart the knowledge on importance and cultivation of specialty flowers, fillers and cut green crops.

The course is organized as follows

S. No	Blocks	Units
1	Scope	1. Importance, national and international scenario
2	Avenues	1. Specialty flowers
		2. Fillers
		3. Cut greens
3	Trade and marketing	1. Post harvest management and marketing 2. Standards

LEARNING OUTCOMES

After successful completion of this course,

- The students will gain knowledge on different specialty flowers, cut greens, fillers their cultivation practices and post harvest management.
- Infuse confidence to take up cultivation as an enterprise.

THEORY

Block 1: Scope

UNIT I: Importance, national and international scenario: Introduction, present status, scope, importance and avenues for specialty flowers and cut greens.

Block 2: Avenues

UNIT I: Specialty flowers: Cultivation practices of specialty flower crops like heliconia, red ginger, Bird of Paradise, Ornamental banana, ornamental curcuma, gingers, wax flower, kangaroo paw, limonium, rice flower, *etc.*

UNIT II: Fillers: Cultivation practices of fillers like gypsophila, solidago, Mollucella, lupins, *etc.*

UNIT III: Cut greens: Cultivation practices of cut greens like anthurium, ferns, asparagus, cycas, thuja, bottle brush, ornamental palms, zantedhoefia, dracaena, eucalyptus, ruscus, dianella, alpinia, *etc.*

Block 3: Trade and Marketing

UNIT I: 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

UNIT II: Standards: Quality standards, Packaging standards, marketing and trade in important flower, filler and foliage crops.

PRACTICALS (16)

1. Identification of specialty flowers, fillers and cut greens (2)
2. Media and bed preparation for cultivation (2)
3. Propagation of important crops (2)
4. Integrated disease and pest management in important crops (2)

5. Post harvest handling of specialty flowers, fillers and cut greens (2)
6. Preparation of value added products from important specialty flowers, fillers and foliage (2)
7. Exposure visits (2)
8. Economics and Project preparation (2)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Armitage, A. M. & Laushman, J. M. 2008. *Speciality Cut Flowers*. Timber Press. 2nd Edition, pp. 636.
- Bhattacharjee, S. K. 2006. *Vistas in Floriculture*. Pointer Publ., Jaipur, India.
- Bhattacharjee, S. K. & De, L.C. 2003. *Advanced Commercial Floriculture* Vol.1. Aavishkar Publ. & Distributors, Jaipur India.
- Bose, T. K., Yadav, L. P., Pal, P., Parthasarathy, V.A. & Das, P. 2003. *Commercial Flowers*. Vol. I & II. Naya Udyog, Kolkata, India.
- Misra, R. L. & 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, N. R. & Desai, B. B. 2004. *Post harvest Biotechnology of Flowers and Ornamental Plants*. Naya Prokash, Kolkata, India.

FLS 604: BIOTECHNOLOGICAL APPROACHES IN FLORICULTURAL CROPS (2+1)

WHY THIS COURSE?

This course deals with advances in biotechnology of flower crops. The student needs to be abreast with recent advances in tissue culture, genetic engineering and molecular biology of flower crops

AIM OF THIS COURSE:

Equip the students with the advances in application of biotechnology in flower crops.

S.No	Blocks	Units
1	Scope of biotechnology	1. Scope of biotechnology
2	Cell, Tissue and Organ culture	1. Tissue cultures
		2. Somaclonal variation and <i>in vitro</i> conservation
3	Genetic engineering and molecular biology	1. Genetic Engineering
		2. Molecular approaches

THEORY

Block 1: Scope of biotechnology

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

Block 2: Cell, tissue and organ culture

UNIT I: Micropropagation: In vitro lines for biotic and abiotic stress – Meristem culture for disease elimination, production of haploids through anther and pollen culture – embryo and ovule culture, micrografting, wide hybridization and embryo rescue techniques, construction of somatic hybrids and cybrids, regeneration and characterization of hybrids and cybrids, in vitro pollination and fertilization, hardening media, techniques and establishment of tissue culture plants in the primary and secondary nursery in important flower crops.

UNIT II: Somaclonal variation and *in vitro* conservation: Somaclonal 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.

Block 3: Genetic engineering and molecular biology

UNIT I: 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 & PAGE techniques; identification of molecular markers in important flower crops.

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

PRACTICALS

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

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Chopra, V. L. & 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, M. D. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall Publ.

Gorden, H. & Rubsell, S. 1960. *Hormones and Cell Culture*. AB Book Publ.

Keshavachandran, R., Nazeem, P. A., Girija, D., John, P. S. & Peter, K. V. 2007. *Recent Trends in Horticultural Biotechnology*. Vols. I & II, 1018 p.. New India Publ. Agency, New Delhi, India.

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

FLS 605 VERTICAL GARDENING (1+2)

WHY THIS COURSE?

This course deals with development in vertical gardening which is expanding across the country. In view of the unprecedented pollution, advent of smart cities demand for green walls/living walls is increasing day by day. The students therefore need to be equipped with the advancements taking place to offer solutions.

AIM OF THIS COURSE:

Equip the students with the latest developments in vertical gardening.

S.No	Blocks	Units
1	Importance	1. Scope
		2. Growth
		3. Making of vertical garden
2	Green roofing	1. Green facades
		2. Mitigation of pollution
		3. Maintenance

THEORY

Block 1: Importance

UNIT I: Scope: Present status of vertical gardening, benefits of vertical gardening, History of vertical gardens, role of indoor plants in mitigating pollution.

UNIT II: Growth: Factors influencing the growth and development of the plants including light, humidity, temperature, nutrition, irrigation, growth regulation.

Unit 3: Making of vertical gardens: Containers, media, frames, cost effective components, cables, wires, nets for the vertical formations, modular living walls,

Block 2: Green roofing

UNIT I: Green Facades: Influence of green facades in providing thermal comfort, atmospheric cleansing and related environmental benefits, Energy saving potential of greenfaçades, Aesthetic appeal of green structures and other relevant studies on urban greening UNIT II: Mitigation of pollution: Plants suitable, Dust mitigation, Radiation absorption, Pollution mitigation, Acoustic attributes of urban greening

UNIT III: Maintenance: Lifecycle, maintenance, Plants with low light, medium, high intensity requirement, cost effectiveness and overall sustainability of living walls

PRACTICALS

1. Identification of plants (2)
2. Components of vertical gardens (2)
3. Designing of vertical gardens for different locations (4)
4. Maintenance of vertical gardens (2)
5. Economics (1)
6. Project preparation (1)
7. Exposure visit (4)

TEACHING METHODS/ACTIVITIES

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

- Hands on training of different techniques
- Exposure visits

RESOURCES

Chopra, V. L. & 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, M. D. 1984. *Gene Cloning: The Mechanics of DNA Manipulation*. Chapman & Hall Publ.

Gorden, H. & Rubsell, S. 1960. *Hormones and Cell Culture*. AB Book Publ.

Keshavachandran, R., Nazeem, P. A., Girija, D., John, P. S. & Peter, K. V. 2007. *Recent Trends in Horticultural Biotechnology*. Vols. I & II, pp. 1018. New India Publ. Agency, New Delhi, India.

Keshavachandran, R. & Peter, K. V. 2008. *Plant Biotechnology: Methods in Tissue Culture and Gene Transfer*. Orient Blackswan. pp. 312.

FLS 606: ADVANCES IN BREEDING OF FLOWER CROPS (2+1)

WHY THIS COURSE?

There have been several advances in application of biotechnology of flower crops. The students need to be aware of a wide array of *in vitro* and molecular techniques with reference to flower crops.

AIM OF THIS COURSE:

To teach students about the recent research trends in the field of breeding of ornamental crops with special emphasis on biotechnological approaches.

The course is organized as follows:

S.No	Blocks	Units
1	<i>In vitro</i> techniques and biosynthetic pathways	1. <i>In vitro</i> techniques
		2. Biosynthetic pathways
2	Molecular techniques	1. Molecular breeding
		2. Genome editing
		3. Advances in flower crops

LEARNING OUTCOMES

After successful completion of this course,

1. The students will have in depth knowledge and hands on training in *in vitro* and molecular approaches that can be used in flower crops.
2. Equip the students with the skills for develop designer crops

THEORY

Block 1: *In vitro* techniques and biosynthetic pathways

UNIT I: *In vitro* techniques: Role of biotechnology in improvement of flower crops; *in vitro* mutagenesis, embryo culture, somaclonal variation, transformation, *in vitro* cryopreservation, somatic hybridization, anther and ovule culture including somatic embryogenesis.

UNIT II: Biosynthetic pathways: Biosynthetic pathways of pigment, fragrance and senescence, flower form; chemistry and importance of secondary metabolites, genomics, proteomics, metabolomics.

Block 2: Molecular techniques

UNIT I: Molecular breeding: Molecular breeding and Marker assisted selection; molecular characterization; construction of c-DNA library; High throughput sequencing.

UNIT II: Genome editing: Genome editing, CRISPER CAS, gene pyramiding, allele mining

UNIT III: Advances in flower crops: Breeding for biotic and abiotic stresses using biotechnological means; designer flower crops. Advancements in important flower crops like rose, chrysanthemum, carnation, orchids, anthuriums, lily, gerbera etc.,

PRACTICALS (16)

1. *In vitro* mutagenesis, embryo culture, somaclonal variation (2)
2. Somatic hybridization, anther and ovule culture and somatic embryogenesis (2)
3. Genetic transformation (2)
4. Genetic fingerprinting, Genome editing techniques (4)
5. PCR, genomics, blotting techniques (2)
6. Cloning, marker assisted selection (2)
7. Bioinformatics (2)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

- Anderson, N. O. 2007. *Flower Breeding and Genetics Issues, Challenges and Opportunities for the 21st Century*. Springer Publ., The Netherlands.
- Arthur, M. L. 2013. *Introduction to Bioinformatics*. Oxford University Press, U.K. 400 p.
- Chadha, K. L. & Chaudhury, B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
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FLS 607: ADVANCES IN PRODUCTION TECHNOLOGY OF FLOWER CROPS (2+1)

WHY THIS COURSE?

Production technology of flower crops is undergoing a rapid change due to advances from other sciences. The students need to keep abreast with these advances in production technology in flower crops.

AIM OF THIS COURSE:

To keep abreast with latest developments and trends in production technology of flower crops.

The course is organized as follows:

S.No	Blocks	Units
1	Production technology	1. Scope and scenario
		2. Cultural operations
		3. Crop regulation
		4. Advances in production technology of flowers
2	Mechanization and Post harvest management	1. Mechanization
		2. Post harvest management

LEARNING OUTCOMES

After successful completion of this course,

1. The students will acquire knowledge and skills in advances in production technology, crop regulation and mechanization in flower crops.
2. Develop enterprising attitude among students.

THEORY

Block 1: Production technology

UNIT I: Scope and scenario: Commercial flower production; Scope and importance; Global Scenario in cut flower production and trade, varietal wealth and diversity; Soil and Environment; cut flower, loose flowers, dry flowers and essential oil trade, flower seed production. Special characteristics and requirements. Essential oil industry, recent advances in extraction methods.

UNIT II: Cultural operations: Propagation and multiplication; Greenhouse management; Soil/media decontamination techniques; Microirrigation; nutrition and fertigation; slow release fertilizers and biofertilizers; influence of environmental parameters, light, temperature, moisture, humidity and CO₂ on growth and flowering.

UNIT III: 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.

UNIT IV: Advances in production technology of crops: Advances in roses, chrysanthemum, carnation, tuberose, gladiolus, lily, gerbera, orchids, anthuriums, etc.,

Block 2: Mechanization and Post harvest management

UNIT I: Mechanization: Mechanization, automation, ICT and AI in floriculture.

UNIT II: Post harvest management: Harvest indices, Harvesting techniques; Post harvest handling for local, distant and export market, Cluster production, Contract farming, FPOs, Value chain management.

PRACTICALS (16)

1. Greenhouse management; Soil decontamination techniques (2)
2. Microirrigation; Nutrition and fertigation (2)
3. Special practices- bending, netting, pinching, disbudding, defoliation and chemical pruning etc (2)

4. Photoperiodic and chemical induction of flowering (2)
5. Assessing harvest indices; Post-harvest handling (2)
6. Case studies (2)
7. Visit to commercial cut flower and essential oil units (4)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

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- Chadha, K. L. & Choudhury, B. 1992. *Ornamental Horticulture in India*. ICAR, New Delhi, India.
- George, S. & Peter, K. V. 2008. *Plants in a Garden*. New India Publ. Agency, New Delhi, India.
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- Randhawa, G.S. & Mukhopadhyay, A. 1986. *Floriculture in India*. Allied Publ.
- Reddy, S., Janakiram, T., Balaji T., Kulkarni, S. & Misra, R. L. 2007. *Hi- Tech Floriculture*. Indian Society of Ornamental Horticulture, New Delhi India.
- Singh, A. K. 2006. *Flower Crops: Cultivation and Management*. New India Publ. Agency, New Delhi, India.
- Singh, A. K. 2014. *Breeding and Biotechnology of Flowers, Vol.1: Commercial Flowers*. New India Publ. Agency, New Delhi, India. pp.740.

FLS 608: ADVANCES IN PROTECTED CULTIVATION OF FLOWER CROPS(2+1)

WHY THIS COURSE?

Protected cultivation is more rewarding in production of high value cut flowers. With appropriate structures and plant environment control measures, the constraints of environment prevalent in the region can be overcome allowing almost year-round cultivation. The students need to get updated with the recent advances in protected cultivation.

AIM OF THIS COURSE:

Appraisal on the advances in protected and precision farming of flower crops. The course is organized as follows:

S.No	Blocks	Units
1	Production technology	1. Scope and Scenario
		2. Microclimate management
		3. Cultural operations
		4. Advances in flower crops
2	Precision floriculture and regulations	1. Precision floriculture
		2. Regulations

LEARNING OUTCOMES

After successful completion of this course,

- The students will be abreast with the recent advances in protected cultivation of flower crops
- Equip the students with skill to independently manage enterprises

THEORY

Block 1: Production technology

UNIT I: Scope and Scenario: Prospects of protected floriculture in India, growing structures, basic considerations in establishment and operation of green houses, functioning and maintenance. Global trade, forward and backward linkages for import clusters, International and national auction houses.

Unit II: Microclimate management: Environmental control systems in greenhouse, regulation of light through LEDs containers, substrate culture, soil decontamination techniques, aeroponics, hydroponics and vertical farming.

UNIT III: Cultural operations: Water and nutrient management, crop regulation, special horticultural practices under protected cultivation of rose, chrysanthemum, carnation, orchids, anthurium, gerbera, lily, cut foliage and potted ornamental crops; plant architecture management in ornamental plants.

UNIT IV: Advances in flower crops: Advances in protected cultivation of important flowering (rose, chrysanthemum, carnation, gerbera, orchids, anthurium, lily, and foliage plants (aglaonema, monstera, dracaena, syngonium, pothos, diffenbachia etc)

Block 2: Precision floriculture and regulations

UNIT I: 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.

UNIT II: Regulations: PBR / IPR issues; Forward and backward linkages, 100% EOU, packaging and export standards, Cold chain Management, non-tariff barriers, APEDA regulations for export, marketing channels, auction houses, major markets.

PRACTICALS

1. Growing structures, basic considerations in establishment and operation of greenhouses.
2. Environmental control systems in greenhouse.
3. Containers, substrate culture, soil decontamination techniques.
4. Crop regulation.
5. Special horticultural practices under protected cultivation.
6. Precision equipments, computers and robotics in precision farming.
7. Harvest indices – harvesting, Post harvest handling, marketing.
8. Export and cold chain management.

TEACHING METHODS/ACTIVITIES

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

RESOURCES

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

Bose, T.K., Maiti, R.G., Dhua, R.S. & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.

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

FLS 609: ADVANCES IN LANDSCAPE GARDENING (1+2)

WHY THIS COURSE?

Advances in landscape gardening is a course which deals with principles of landscape design, landscape engineering and site analysis. It will also create awareness on latest developments in landscape gardening among students.

AIM OF THIS COURSE:

To update knowledge on the recent trends in the field of landscape designing and developing practical skills.

The course is organized as follows:

S.No	Units
1	Landscape design
2	Site analysis
3	Software in landscaping
4	Landscaping for different situations
5	Maintenance

LEARNING OUTCOMES

After successful completion of this course,

- The students will be abreast with the recent advances in landscape gardening
- Acquire the skills to independently handle landscape projects

THEORY

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

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

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

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

UNIT V: 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.,

PRACTICALS (32)

1. Plant identification (1)
2. Materials of garden design, Design making by different garden styles and types (2)
3. Assessing site and plants adaptability for different locations (2)
4. Way of designing a commercial landscape project (4)
5. Landscape engineering (Topographical survey and designing concept) (2)
6. Preparation and drawing of site plan (4)

7. Learning the basics in computer aided design (CAD) for developing a gardenlandscape plan (4)
8. Handling soft landscape materials (AUTOCAD & ARCHICAD), GIS as a tool for spatial designing (4)
9. Case study with the successful landscapist (4)
10. Budget/Project cost estimating (2)
11. Exposure visits (3)

TEACHING METHODS/ACTIVITIES

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

RESOURCES

Bose, T.K., Maiti, R.G., Dhua, R.S. & Das P. 1999. *Floriculture and Landscaping*. Naya Prokash, Kolkata, India.

Nambisan, K.M.P. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH Publ. Co., New Delhi, India.

Ozayuvuz, M. 2013. *Advances in Landscape Architecture*. In Tech Open Publ.

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

PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS (PSM)

M. Sc. (Hort.) Plantation, Spices, Medicinal and Aromatic Crops

Code	Course	Credit hours
Major Courses (20 Credits)		
PSM 501*	Production of Plantation Crops	2+1
PSM 502*	Production of Spice Crops	2+1
PSM 503*	Production of Medicinal and Aromatic Crops	2+1
PSM 504*	Breeding of Plantation and Spice Crops	2+1
PSM 505*	Breeding of Medicinal and Aromatic Crops	1+1
PSM 506	Systematics of Plantation and Spice Crops	1+1
PSM 507	Systematics of Medicinal and Aromatic Crops	1+1
PSM 508	Underexploited Plantation, Spice, Medicinal and Aromatic Plants	2+0
PSM 509	Growth and Development of Plantation, Spice, Medicinal and Aromatic Crops	2+1
PSMA 510	Biochemistry of Plantation, Spices, Medicinal and Aromatic crops	2+1
PSMA 511	Biodiversity and Conservation of Plantation, Spices, 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

Ph. D.(Hort.) Plantation, Spices, Medicinal and Aromatic Crops

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

* Compulsory among major courses

M.Sc. Syllabus

PSM 501: PRODUCTION OF PLANTATION CROPS (2+1)

WHY THIS COURSE?

Plantation crops play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers. This course will impart theoretical as well as hands-on experience to the learner on scientific production technology of various plantation crops in Indian perspectives. It will provide comprehensive knowledge in this regard.

AIM OF THIS COURSE:

The course is designed to provide both basic and applied knowledge on various aspects of production technology of plantation crops grown in India.

LEARNING OUTCOME

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

- Develop the technical skill in commercial cultivation of plantation crops
 - Be able to start plantation crop-based enterprises
- The course is organized as follows:

S.No	Blocks	Units
1	Importance of Plantation Crops	1. Role of plantation crops
		2. Export potential
		3. Promotional programmes
2	Production Technology	1. Varietal wealth
		2. Propagation and nursery management
		3. Agro techniques
3	Harvest and Post harvest management	1. Maturity indices and harvest 2. Post harvest management

THEORY

Block 1: Importance of Plantation Crops

UNIT 1: Role of plantation crops: Role of plantation crops in national economy, area- production statistics at national and international level, classification, clean development mechanism and carbon sequestration potential of plantation crops

UNIT 2: Export potential: Export potential, problems and prospects and IPR issues in plantation crops

UNIT 3: Promotional programmes: Role of commodity boards and directorates in the development programmes of plantation crops

Block 2: Production Technology

UNIT 1: Varietal wealth: Botany, taxonomy, species, cultivars and improved varieties in plantation crops

UNIT 2: Propagation and nursery management: Plant multiplication including *in vitro* multiplication, nursery techniques and nursery management in plantation crops

UNIT 3: Agro techniques: Systems of cultivation, cropping systems, multitier cropping, climate and soil requirements, systems of planting, high density planting, nutritional requirements, water requirements, fertigation, moisture conservation, role of growth regulators, macro and micro nutrients, nutrient deficiency symptoms, physiological disorders, shade regulation, weed management, training and pruning, crop regulation, plant protection, management of drought, precision farming.

Block 3: Harvest and Post harvest management

UNIT 1: Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons and mechanized harvesting in plantation crops

UNIT 2: Post harvest management: Post harvest handling including primary processing, grading, packaging, storage and benefit cost analysis of plantation crops

CROPS: Coconut, Arecanut, Oilpalm, Cashew, Coffee, Tea, Cocoa, Rubber, Palmyrah, Betel vine

PRACTICALS

1. Description of botanical and varietal features
2. Selection of mother palms and seedlings
3. Nursery techniques
4. Soil and water conservation measures
5. Nutrient deficiency symptoms
6. Manuring practices
7. Pruning and training methods
8. Maturity standards
9. Harvesting
10. Project preparation for establishing plantations
11. GAP in plantation crops
12. Exposure visits to commercial plantations, research institutes

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

RESOURCES

- Afoakwa, E. O. 2016. *Cocoa Production and Processing Technology*. CRC Press
- Anonymous, 1985. *Rubber and its Cultivation*. The Rubber Board of India.
- Chopra, V. L. and Peter, K. V. 2005. *Handbook of Industrial Crops*. Panama.
- Choudappa, P., Anitha, K., Rajesh, M. K., and Ramesh, S. V. 2017. *Biotechnology of Plantation Crops*. Daya Publishing House, New Delhi
- Choudappa, P., Niral, V., Jerard, B. A., 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, C. R. 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, K. V. 2007. *Commercial Crops Technology*. New India Publ. Agency.
- Nair, M. K, Bhaskara Rao, E. V. V., Nambia, K. K. N., and Nambiar, M. C. 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, K. V. 2002. *Plantation Crops*. National Book Trust. New Delhi
- Pillay, P. N. R. 1980. *Handbook of natural rubber production in India*. Rubber Research Institute, Kottayam. pp.668
- Pradeepkumar, T., Suma, B., Jyothi bhaskar and Satheesan, K. N. 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 C.R., Pandey A., Roussos S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.

Sethuraj, M. R. and Mathew, N. T. 1992. *Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science)*. Elsevier Science.

Sharangi, A. B. and Datta, S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.

Sharangi, A. B. and Acharya, S.K. 2008. *Quality management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2

Srivastava, H. C, Vatsya., and Menon, K. K. G. 1986. *Plantation Crops – Opportunities and Constraints*. Oxford and IBH.

Thampan, P. K. 1981. *Hand Book of Coconut Palm*. Oxford and IBH.

PSM 502: PRODUCTION OF SPICE CROPS (2+1)

WHY THIS COURSE?

Spice crops play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers. This course will impart theoretical as well as hands-on experience to the learner on scientific production technology of various spice crops in Indian perspectives. It will provide comprehensive knowledge in this regard.

AIM OF THIS COURSE:

The course is designed to provide both basic and applied knowledge on various aspects of production technology of spice crops grown in India.

The course is organized as follows:

S.No	Blocks	Units
1	Importance of Spice Crops	1. Role of spice crops 2. Classification of spice crops
2	Production Technology	1. Varietal wealth 2. Propagation and nursery management 3. Agro techniques
3	Harvest and Post harvestmanagement	1. Maturity indices and harvest 2. Post harvest management

LEARNING OUTCOME

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

- Develop the technical skill in commercial cultivation of spice crops
- Be able to start spice-based enterprises

THEORY

Block 1: Importance of spice crops

UNIT 1: Role of Spice crops: Introduction, importance of spice crops, pharmaceutical significance, historical accent, present status – national and international, future prospects, role of Spices board and other development agencies

UNIT 2: Classification of spice crops: Major spices, minor spices, seed spices, tree spices, herbal spices

Block 2: Production Technology

UNIT 1: Varietal wealth: Botany and taxonomy, species, cultivars, commercial varieties/hybrids in spice crops

UNIT 2: Propagation and nursery management: Seed, vegetative and micro-propagation methods, nursery techniques and nursery management practices

UNIT 3: Agro techniques: Climatic and soil requirements, site selection, layout, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, plant protection, precision farming, physiological disorders, protected cultivation

Block 3: Harvest and Post harvest management

UNIT 1: Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons, mechanized harvesting

UNIT 2: Post harvest management: Post harvest management including primary processing, grading, packaging and storage, GMP in major spice crops

CROPS: Black pepper, small and large Cardamom, Turmeric, Ginger, Garlic, Coriander, Fenugreek, Cumin, Fennel, Ajwain, Saffron, Vanilla, Nutmeg, Clove, Cinnamon, Allspice, Tamarind, Garcinia

PRACTICALS

1. Identification of seeds and plants
2. Botanical description of plant
3. Varietal features
4. Planting material production
5. Field layout and method of planting
6. Cultural practices
7. Harvest maturity, harvesting
8. Drying, storage, packaging
9. Primary processing
10. GAP in spice crops
11. GMP in spice crops
12. Short term experiments on spice crops
13. Exposure visits to spice farms, research institutes

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

RESOURCES

- Agarwal, S., Sastry, E. V. D., and Sharma, R. K. 2001. *Seed Spices: Production, Quality, Export*. Pointer Publ.
- Arya, P. S. 2003. *Spice Crops of India*. Kalyani.
- Bose, T. K., Mitra, S. K., Farooqi, S. K., and Sadhu, M. K. (Eds.). 1999. *Tropical Horticulture*. Vol. I. Naya Prokash.
- Chadha, K. L. 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, N. A., Khader, P., Rangaswami and Irulappan, I. 2000. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. Oxford and IBH.
- Nybe, E. V., Miniraj, N. and Peter, K. V. 2007. *Spices*. New India Publ. Agency.
- Parthasarthy, V. A., Kandiannan V. and Srinivasan V. 2008. *Organic Spices*. New India Publ. Agency.
- Peter, K. V. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ. Co. UK and CRC USA
- Ponnuswami, V. et al (2018) *Medicinal Herbs and herbal cure*. Narendra Publishing House, New Delhi
- Pruthi, J. S. (Ed.). 1998. *Spices and Condiments*. National Book Trust
- Pruthi, J. S. 2001. *Minor Spices and Condiments- Crop Management and Post Harvest Technology*. ICAR.
- Purseglove, J. W., Brown, E. G., Green, C. L., and Robbins, S. R. J. (Eds.). 1981. *Spices*. Vols. I, II. Longman.
- Ramachandra et al (2018) *Breeding of Spices and Plantation crops*. Narendra Publishing House, New Delhi
- Ravindran, P. N. 2000. *Black pepper, Piper nigrum*. CRC press
- Ravindran, P. N. 2002. *Cardamom, the genus Elettaria*. CRC press
- Ravindran, P. N. 2003. *Cinnamon and cassia*. CRC press

- Ravindran, P. N. 2004. *Ginger, the genus Zingiber*. CRC press
- Ravindran, P. N. 2007. *Turmeric, the genus curcuma*. CRC press
- Ravindran, P. N. 2017. *The Encyclopedia of Herbs and Spices*. CABI
- Shanmugavelu, K. G, Kumar, N., and Peter, K.V. 2002. *Production Technology of Spices and Plantation Crops*. Agrobios.
- Sharangi, A. B, Datta, S. and Deb, P. 2018. Spices “*Agrotechniques for quality produce*”. Apple Academic Press (Tylor and Francis Groups), New Jersey, USA
- Sharangi, A. B. 2018. Indian Spices “*The legacy, production and processing of India’s treasured export.*” Springer International publishing AG, Part of Springer Nature 2018, Cham, Switzerland.
- Sharangi, A. B. and Datta, S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.
- Sharangi, A. B. and Acharya, S.K.2008. *Quality management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2
- Thamburaj , S and Singh, N. (Eds.). 2004. *Vegetables, Tuber Crops and Spices*, ICAR.
- Tiwari, R. S.and Agarwal, A. 2004. *Production Technology of Spices*. International Book Distr. Co.

PSM 503: PRODUCTION OF MEDICINAL AND AROMATIC CROPS (2+1)

WHY THIS COURSE?

Medicinal and aromatic crops play an important role in the national economy of India. These crops also provide health security to all. This course will impart theoretical as well as hands- on experience to the learner on scientific production technology of various medicinal and aromatic crops in Indian perspectives. It will provide comprehensive knowledge in this regard.

AIM OF THIS COURSE:

To impart comprehensive knowledge on the production technology of important medicinal and aromatic crops

The course is organized as follows:

S.No	Blocks	Units
1	Importance of Medicinal and Aromatic Crops	1. Classification of medicinal and aromatic crops 2. Medicinal plant based industry 3. Aromatic plant based industry
2	Production technology	1. Varietal wealth 2. Propagation and nursery management 3. Agro techniques
3	Harvest and Post harvest management	1. Maturity indices and harvest 2. Post harvest management

LEARNING OUTCOME

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

- Develop the technical skill in commercial cultivation of medicinal and aromatic crops
- Be able to start medicinal and aromatic crop-based enterprises

THEORY

Block 1: Importance of Medicinal and Aromatic Crops

UNIT 1: Classification of medicinal and aromatic crops: Importance of medicinal plants, Importance of aromatic plants, Role in national economy, utility sectors of medicinal and aromatic crops, classification of medicinal and aromatic crops, role of institutions, Medicinal Plant Board and NGO's in research and development of medicinal and aromatic crops

UNIT 2: Medicinal and plant based industry: Indian system of medicine, traditional systems of medicine, tribal medicine, medicinal industry, source of medicinal plants, area, production, export and import of major crops, problems, prospects and challenges, IPR issues

UNIT 3: Aromatic plant based industry: Essential oils, classification, physical and chemical properties and storage of essential oils. Indian perfumery industry, area, production, export and import status of major aromatic crops, history and advancements, problems, prospects and challenges, IPR issues

Block 2: Production technology of medicinal and aromatic crops

UNIT 1: Varietal wealth: Botany and taxonomy, species, cultivars, commercial varieties/hybrids in medicinal and aromatic crops

UNIT 2: Propagation and nursery management: Seed, vegetative and micro-propagation methods, nursery techniques and nursery management practices

UNIT 3: Agro techniques: Climatic and soil requirements, site selection, layout, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, plant protection

Block 3: Harvest and Post harvest management

UNIT 1: Maturity indices and harvest: Maturity indices, harvesting methods, harvesting seasons in medicinal and aromatic crops

UNIT 2: Post harvest management: Post harvest management including primary processing, extraction, grading, packaging and storage, GMP in medicinal and aromatic crops

CROPS:

A. Medicinal crops: Senna, periwinkle, medicinal coleus, aswagandha, glory lily, sarpagandha, *Dioscorea* sp., *Aloe vera*, *Andrographis paniculata*, *Digitalis*, medicinal solanum, isabgol, opium poppy, safedmusli, *Stevia rebaudiana*, *Mucuna pruriens*, *Piper longum*, *Plumbago zeylanica*

B. Aromatic crops: Palmarosa, lemongrass, citronella, vetiver, mentha, patchouli, sweet flag, jasmine, geranium, artemisia, lavender, *Ocimum* sp., eucalyptus, sandal

PRACTICALS

1. Description of botanical and varietal features
2. Nursery techniques
3. Lay out and planting
4. Manuring practices
5. Maturity standards
6. Harvesting
7. Primary processing
8. Extraction of oils
9. Herbarium preparation
10. Project preparation for establishing herbal gardens
11. GAP in medicinal and aromatic crops
12. GMP in medicinal and aromatic crops
13. Exposure visits to institutes, herbal gardens and industries

TEACHING METHODS/ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

RESOURCES

Atal, C. K. and Kapur, B. M. 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, A. A. and Sriram, A. H. 2000. *Cultivation Practices for Medicinal and Aromatic Crops*. Orient Longman Publ.

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

Hota, D. 2007. *Bio Active Medicinal Plants*. Gene Tech Books.

Jain SK. 2000. *Medicinal Plants*. National Book Trust.

Khan, I. A. 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.

Ponnuswamiet *al.*, 2018 Medicinal Herbs and herbal cure. Narendra Publishing House, NewDelhi

Prajapati, S. S, Paero, H, Sharma, A. K. and Kumar, T. 2006. *A Hand book of Medicinal Plants*. Agro Bios.

Ramawat, K. G.,and Merillon, J. M. 2003. *BioTechnology – Secondary Metabolites*. Oxford and IBH.

Shankar, S.J. 2018. *Comprehensive post harvest technology of flowers, medicinal and aromatic plants*. Narendra Publishing House, New Delhi

Skaria, P. B., Samuel, M., Gracy Mathew, Ancy Joseph, Ragina Joseph. 2007. *Aromatic Plants*. New India Publ. Agency.

PSM 504: BREEDING OF PLANTATION AND SPICE CROPS (2+1)

WHY THIS COURSE?

Plantation and spice crops play an important role in the national economy of India. For maximizing the production, productivity and quality of plantation and spice crops, fundamental knowledge on breeding methods of the major crops is essential. This course will impart theoretical as well as hands-on experience to the learner on reproductive biology, breeding methods and breeding achievements in various plantation and spice crops

AIM OF THIS COURSE:

To impart comprehensive knowledge on the principles and practices in the breeding of important plantation and spice crops

The course is organized as follows:

S.No	Blocks	Units
1	Genetic diversity	1.Species and cultivar diversity 2.Germplasm evaluation
2	Crop improvement	1. Breeding objectives 2. Breeding methods
3	Breeding achievements and future thrusts	1. Breeding achievements 2. Future thrusts

LEARNING OUTCOME:

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

- Develop the technical skill in breeding of plantation and spice crops
- Be able to start plantation and spice crop-based seed production/nursery centres

THEORY

Block 1: Genetic diversity

UNIT 1: Species and cultivar diversity: Floral and reproductive biology, cytogenetics, male sterility, incompatibility, wild and cultivated species, popular cultivars

UNIT 2: Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm

Block 2: Crop improvement

UNIT 1: Breeding objectives: Breeding objectives/goals on the basis of yield, quality, stress tolerance, adaptation

UNIT 2: Breeding methods: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses

Block 3: Breeding achievements and future thrusts

UNIT 1: Breeding achievements: Breeding achievements in terms of released varieties, parentage, salient features

UNIT 2: Future thrusts: Molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climate resilience

CROPS

A. Plantation crops: Coconut, Arecanut, Cashew, Cocoa, Rubber, Oil palm, Coffee, Tea, Palmyrah, Betel vine

B. Spice crops: Black pepper, small and large cardamom, Ginger, Turmeric, Fenugreek, Coriander, Fennel, Cumin, Ajwain, Garlic, Nutmeg, Cinnamon, Clove, Allspice, Garcinia, Tamarind

PRACTICALS

1. Characterization and evaluation of germplasm
2. Floral biology, anthesis; pollen behaviour, fruit set
3. Practices in hybridization, selfing and crossing techniques
4. Polyploidy breeding
5. Mutation breeding
6. Induction of somaclonal variation and screening the variants
7. Evaluation of biometrical traits and quality traits
8. Salient features of improved varieties and cultivars
9. Screening for biotic and abiotic stresses
10. Bioinformatics
11. Exposure visits to research institutes for plantation and spice crops

TEACHING METHODS/ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

RESOURCES

- Afoakwa, E. O. 2016. *Cocoa Production and Processing Technology*. CRC Press
- Anonymous. 1985. *Rubber and its Cultivation*. The Rubber Board of India.
- Chadha, K. L, Ravindran, P. N and Sahijram, L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.
- Chadha, K. L. 1998. *Advances in Horticulture*. Vol. IX,X.. *Plantation and Spices Crops*. Malhotra Publishing House, New Delhi.
- Chadha, K. L. and Rethinam, P. (Eds.). 1993. *Advances in Horticulture*. Vol. IX. *Plantation Crops and Spices*. Part-I. Malhotra Publ. House.
- Chopra, V. L. and Peter, K. V. 2002. *Handbook of Industrial Crops*. Haworth Press, USA and. Panama International Publ. (Indian Ed.).
- Choudappa, P., Anitha, K., Rajesh, M. K., and Ramesh, S. V. 2017. *Biotechnology of Plantation Crops*. Daya Publishing House, New Delhi
- Damodaran, V. K., Vilaschandran, T., and Valsalakumari, P. K. 1979. *Research on Cashew in India*. KAU, Trichur.
- Devi, A. R, Sharangi, A B, Acharya, S K and Mishra G C, 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, A. E. 1962. *Modern Coffee Production*. Leonard Hoff.
- Kumar, N. 2017. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants*. CBS Publishers
- Nybe., E. V, MiniRaj, N and Peter, K. V. 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, P. N. R. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668

Ponnuswamiet al. 2018. *Blossom biology of Horticultural crops*. Narendra Publishing House, New Delhi

Ponnuswamiet al. 2018. *Botany of Horticultural crops*. Narendra Publishing House, New Delhi

Ponnuswamiet al. 2018. *Spices*. Narendra Publishing House, New Delhi

Raj, P. S. 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, P.N 2002. *Cardamom, the genus Elettaria*. CRC press

Ravindran, P.N 2003. *Cinnamon and cassia*. CRC press

Ravindran, P.N 2004. *Ginger, the genus Zingiber*. CRC press

Ravindran, P.N 2007. *Turmeric, the genus Curcuma*. CRC press

Ravindran, P.N. 2017. *The Encyclopedia of Herbs and Spices*. CABI

Sera T., Soccol C.R., Pandey A., Roussos S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.

Sethuraj, M. R. and Mathew, N. T. 1992. *Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science)*. Elsevier Science.

Sharangi, A. B. and Datta, S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.

Thampan, P. K. 1981. *Hand Book of Coconut Palm*. Oxford and IBH.

PSM 505: BREEDING OF MEDICINAL AND AROMATIC CROPS (1+1)

WHY THIS COURSE?

Medicinal and aromatic crops play an important role in the national economy of India. For maximizing the production, productivity and quality of medicinal and aromatic crops, fundamental knowledge on breeding methods of the major crops is essential. This course will impart theoretical as well as hands-on experience to the learner on reproductive biology, breeding methods and breeding achievements in various medicinal and aromatic crops.

AIM OF THIS COURSE:

To impart comprehensive knowledge on the principles and practices in the breeding of important medicinal and aromatic crops.

The course is organized as follows:

S.No.	Blocks	Units
1	Genetic diversity	1.Species and cultivar diversity 2.Germplasm evaluation
2	Crop improvement	1. Breeding objectives 2. Breeding methods
3	Breeding achievements and future thrusts	1. Breeding achievements 2. Future thrusts

LEARNING OUTCOME

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

- Develop the technical skill in breeding of medicinal and aromatic crops
- Be able to start medicinal and aromatic crop-based seed production/nursery centres

THEORY

Block 1: Genetic diversity

UNIT 1: Species and cultivar diversity: Floral and reproductive biology, cytogenetics, male sterility, incompatibility, wild and cultivated species, popular cultivars

UNIT 2: Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm, IPR issues

Block 2: Crop improvement

UNIT 1: Breeding objectives: Breeding problems in medicinal and aromatic crops. Genetics of active principles, breeding objectives/goals on the basis of yield, quality, stress tolerance, adaptation

UNIT 2: Breeding methods: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses

Block 3: Breeding achievements and future thrusts

UNIT 1: Breeding achievements: Breeding achievements in terms of released varieties, parentage, salient features

UNIT 2: Future thrusts: Molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climate resilience

CROPS

A. Medicinal crops : *Cassia angustifolia*, *Catharanthus roseus*, *Gloriosa superba*, *Coleus forskohlii*, *Stevia rebaudiana*, *Withania somnifera*, *Papaver somniferum*, *Plantago ovata*, *Chlorophytum* sp., *Rauvolfia*

serpentina, Aloe vera, Piper longum, Plumbago zeylanica

B. Aromatic crops: Mint, geranium, patchouli, lemon grass, palmarosa, citronella, vetiver, Artemisia, ocimum,, lavender , *Kaempferia galanga*, eucalyptus

PRACTICALS

1. Description of botanical features
2. Cataloguing of cultivars, varieties and species in medicinal and aromatic crops
3. Floral biology
4. Selfing and crossing
5. Evaluation of hybrid progenies
6. Induction of economic mutants
7. High alkaloid and high essential oil mutants
8. Evolution of mutants through physical and chemical mutagens
9. Introduction of polyploidy
10. Screening of plants for biotic and abiotic stress
11. *In-vitro* breeding in medicinal and aromatic crops

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

RESOURCES

Chadha, K. L. 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, S. K. 2000. *Medicinal Plants* . National Book Trust.

Julia, F. and Charters, M. C. 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, V. M. 2012. *Quality assurance techniques in pharmaceuticals*. New India Publishing Agency, New Delhi

PSM 506: SYSTEMATICS OF PLANTATION AND SPICE CROPS (1+1)

WHY THIS COURSE?

Plantation and spice crops play an important role in the national economy of India. For the crop improvement programme of these crops, fundamental knowledge on origin and development, evolutionary process, taxonomy and cytogenetics is most essential. This course will impart theoretical knowledge to the learner on the origin and distribution, evolutionary process, taxonomy and cytogenetics of various plantation and spice crops.

AIM OF THIS COURSE:

To impart basic knowledge on the origin and development, evolutionary process, taxonomy, chemotaxonomy, cytogenetics and genetic resources of plantation and spice crops.

LEARNING OUTCOME:

After successful completion of this course:

- The students are expected to have thorough understanding on the systematics of plantation and spice crops. The course is organized as follows:

No	Blocks	Units
1	Origin and evolution	1. Centre of origin 2. Systematics
2	Genetic diversity	1. Species and cultivar diversity 2. Germplasm
3	Cataloguing	1. Descriptors 2. DUS guidelines

THEORY

Block 1: Origin and evolution

UNIT I: Centre of origin: Centre of origin, distribution, taxonomical status, phylogeny

UNIT II: Systematics: Botany, cytology, ploidy status, sex forms, flowering and pollination biology, cytogenetics

Block 2: Diversity

UNIT I: Species and cultivar diversity: Wild and related species, cultivars
UNIT II: Germplasm: Indigenous and exotic germplasm

Block 3: Cataloguing

UNIT I: Descriptors: Biovarsity/NBPGR descriptors and their salient features
UNIT II: DUS guidelines: DUS guidelines, molecular aspects of systematics

CROPS

A. Plantation crops: Coconut, Arecanut, Oil Palm, Tea, Coffee, Cocoa, Cashew, Rubber, Betel Vine

B. Spice crops: Black Pepper, Cardamom, Ginger, Turmeric, Nutmeg, Cinnamon, Clove, Vanilla, Coriander, Fennel, Cumin, Fenugreek, Garlic

PRACTICALS

1. Genus, species and cultivar features of various plantation and spice crops
2. Characterization based on descriptors

3. Characterization based on DUS guidelines
4. Study of sex forms and floral biology
5. Study of molecular markers
6. Exposure visits to national institutes including NBPGR.

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

RESOURCES

- Afoakwa, E, O. 2016. *Cocoa Production and Processing Technology*. CRC Press
- Chadha, K. L. and Gupta, R. 1995. *Advances in Horticulture*. Vol. XI. Malhotra Publ. House.
- Charles Burnham. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications,
- Diwan, A.P and Dhakad, N.K. 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
- Girish Sharma. 2009. *Systematics of fruit Crops*. New India Publishing House, India.
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- Pillay. P. N. R. 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, P.N. 2000. *Black pepper, Piper nigrum*. CRC press
- Ravindran, P.N. 2002. *Cardamom, the genus Elettaria*. CRC press
- Ravindran, P.N. 2003. *Cinnamon and cassia*. CRC press
- Ravindran, P.N. 2004. *Ginger, the genus Zingiber*. CRC press
- Ravindran, P.N. 2007. *Turmeric, the genus curcuma*. CRC press
- Ravindran, P.N. 2017. *The Encyclopedia of Herbs and Spices*. CABI
- Sera, T., Soccol, C.R., Pandey, A., and Roussos S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
- Sethuraj, M. R. and Mathew, N. T. 1992. *Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science)*. Elsevier Science.
- Strickberger, M.W. 2005. *Genetics* (III Ed). Prentice Hall, New Delhi, India
- Tamarin, R.H. 1999. *Principles of Genetics*. Wm. C. Brown Publishers

PSM 507 SYSTEMATICS OF MEDICINAL AND AROMATIC CROPS (1+1)

WHY THIS COURSE?

Medicinal and aromatic crops play an important role in the national economy of India. For the crop improvement programme of these crops, fundamental knowledge on origin and development, evolutionary process, taxonomy and cytogenetics is most essential. This course will impart theoretical knowledge to the learner on the origin and distribution, evolutionary process, taxonomy and cytogenetics of various medicinal and aromatic crops.

AIM OF THIS COURSE:

To impart basic knowledge on the origin and development, evolutionary process, taxonomy, cytogenetics and genetic resources of medicinal and aromatic crops.

The course is organized as follows:

S.No	Blocks	Units
1	Origin and evolution	1.Centre of origin 2.Systematics
2	Genetic diversity	1.Species and cultivar diversity 2.Germplasm
3	Cataloguing	1. Descriptors 2. DUS guidelines

LEARNING OUTCOME:

After successful completion of this course, the students are expected to have thorough understanding on the systematics of medicinal and aromatic crops

THEORY

Block 1: Origin and evolution

UNIT I: Centre of origin: Centre of origin, distribution, taxonomical status, phylogeny, chemotaxonomy

UNIT II: Systematics: Botany, cytology, ploidy status, sex forms, flowering and pollination biology, cytogenetics

Block 2: Diversity

UNIT I: Species and cultivar diversity: Wild and related species, cultivars
UNIT II: Germplasm: Indigenous and exotic germplasm

Block 3: Cataloguing

UNIT I: Descriptors: Biovarsity /NBPGR descriptors and their salient features
UNIT II: DUS guidelines: DUS guidelines, molecular aspects of systematics

CROPS

1. **Medicinal crops:** Opium poppy, Isabgol, Aswagandha, Senna, Medicinal coleus, Glory Lily, Periwinkle, Sarpagandha, Long Pepper, Stevia, Safed musli, *Plumbago zeylanica*

2. **Aromatic crops:** Lemongrass, Citronella, Palmarosa, Vetiver, Mint, Patcholi, Geranium, Ocimum, Rosemary, Lavender, *Kaempferia galanga*, Eucalyptus

PRACTICALS

1. Genus, species and cultivar features of various medicinal and aromatic crops
2. Characterization based on descriptors
3. Characterization based on DUS guidelines
4. Study of sex forms and floral biology

5. Study of molecular markers
6. Exposure visits to national institutes including NBPGR.

TEACHING METHODS/ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

RESOURCES

- Birel Shah and Seth, A.K. 2005. *Text book of Pharmacognosy and Phytochemistry*. CBS Publishers and distributors, New Delhi.
- Charles Burnham. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications
- Diwan, A.P and Dhakad., N.K. 1996. *Genetics and Development*. Anmol Publications Private Limited, New Delhi.
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- Prajapati, N.D., Purohit, S. S., Sharma, A. K, 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.
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- 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, M.W. 2005. *Genetics* (III Ed). Prentice Hall, New Delhi, India
- Tamarin, R.H. 1999. *Principles of Genetics*. Wm. C. Brown Publishers
- Thakur, R. S., Pauri, H. S., and Hussain, A. 1989. *Major Medicinal Plants of India*. CSIR.

PSM 508: UNDEREXPLOITED PLANTATION, SPICE, MEDICINAL AND AROMATIC PLANTS (2+0)

WHY THIS COURSE?

There are many number of underexploited plantation, spice, medicinal and aromatic crops which are becoming important in line with the major ones. They could very well be the major crops of tomorrow. This course will impart comprehensive knowledge to the learner on the importance and scientific production technology of various under utilised plantation, spice, medicinal and aromatic plants in India.

AIM OF THIS COURSE:

To facilitate understanding on the importance and cultivation of underutilized and lesser known plantation, spice, medicinal and aromatic plants.

The course is organized as follows:

S.No	Blocks	Units
1	Importance and status	1. Importance and uses 2.Status and future prospects
2	Production technology	1.Propagation and varieties 2.Agro techniques
3	Harvest and post Harvest management	1.Harvest indices 2.Post harvest management

LEARNING OUTCOME

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

- be thorough with the importance and commercial production technology of underutilized and lesser known plantation, spice, medicinal and aromatic plants.
- be able to start underutilized and lesser known plantation, spice, medicinal and aromatic plants-based enterprises

THEORY

Block 1: Importance and status

UNIT I: Importance and Uses: Introduction, importance, economic parts used, traditional uses

UNIT II: Status and future prospects: Present status, origin, distribution and future prospects of under exploited PSMA

Block 2: Production technology

UNIT I: Propagation and varieties: Propagation and nursery techniques, species varieties UNIT II: Agro techniques: Climatic and soil requirements, planting and after care, weed and water management, manuring, plant protection

Block 3: Harvest and post harvest management

UNIT I: Harvest indices: Maturity indices, harvesting time, techniques, crop duration

UNIT II: Post harvest management: Primary processing, extraction and value addition, storage, active ingredients

CROPS

A. Plantation crops : Wattle, minor species of Areca, Coffea, Hevea

B. Spice crops: *Illicium verum*, *Myristica malabarica*, *M. beddomei*, *Cinnamomum tamala*, *C. malabatrum*, *Xanthoxylum* sp., *Curcuma caesia*, *C. aromatica*, *C. zedoaria*, *C. amada*, *Anethum graveolense*, *Hyssopus officinalis*, *Eringium foetidum*, *Pimpinella anisum*, *Artocarpus lacucha*.

C. Medicinal plants: *Flacourtia montana*, *Plectranthus aromaticus*, *Adhatoda* sp. *Hemidesmus indicus*,

Tinospora cordifolia, *Gymnema sylvestre*, *Psoralea corylifolia*, *Eclipta alba*, *Aristolochia indica*, *Morinda citrifolia*, *Caesalpinia sappan*, *Terminalia chebula*, *T. bellerica*, *Phyllanthus amarus*, *Strychnos nuxvomica*, *S. indicum*, *S. xanthocarpum*, *Aegle marmelos*, *Alpinia* sp., *Hibiscus subdariffa*, *Anthocephalus kadamba*, *Costus* sp., *Kaempferia rotunda*, *K. parviflora*, *Picrorrhiza kurroa*, *Nardostachis jatamansi*, *Valeriana officinalis*, *Swertia chiraita*, *Aconitum* sp., *Salvia officinalis*, *Centella asiatica*, *Bixa orellana*, *Bacopa monnieri*

D. Aromatic plants: *Bursera* sp., *Commiphora wightii*, *Ocimum kilimandjaricum*, *Melaleuca*, *Michaelia champaka*, *Rosa damascena*, *Cananga odorata*, marjoram, chamomile

PRACTICALS

1. Botanical characteristics of species and varieties of various underexploited plantation, spice, medicinal and aromatic plants.
2. Economic parts and their products
3. Propagation and nursery techniques
4. Harvesting and primary processing of under utilised PSMA's
5. Exposure visits to institutes, botanical gardens, herbal gardens and distillation units.

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

RESOURCES

- Atal, C.K. and Kapur, B.M. *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
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- CSIR, The Wealth of India. Volume A-Z CSIR
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- Jain, S. K. 1979. *Medicinal Plants*. National Book Trust.
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- Nybe, E.V., Mini Raj, N and Peter, K.V. 2007. *Spices*. Horticulture Science Series, New India Publ. Agency.
- Peter, K.V. *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, A. B. and Datta, S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.
- Sharangi, A. B., 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, V. V. and Balachandran, I. 1994. *Ayurvedic Drugs and their Plant Sources*. Oxford and IBH.

PSM 509: GROWTH AND DEVELOPMENT OF PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS (2+1)

WHY THIS COURSE?

Understanding on growth and development of plantation, spice, medicinal and aromatic crops is vital towards quality production as well as yield. Fundamental knowledge on developmental physiology, biology and biochemistry and the associated changes is most essential. This course will impart theoretical as well as hands-on experience to the learner on these aspects of PSMA crops for improving their productivity.

AIM OF THIS COURSE:

To impart comprehensive knowledge on the growth, developmental stages and crop regulation to increase the productivity in PSMA

The course is organized as follows:

S.No	Blocks	Units
1	Growth and development	1. Stages of growth 2. Growth pattern 3. Assimilate partitioning
2	Canopy management	1. Canopy management 2. Plant bio regulators
3	Developmental physiology and biochemistry	1. Vegetative phase 2. Flowering and fruit set 3. Growth and development during stress

LEARNING OUTCOME

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

- have thorough understanding on growth and development of PSMA crops
- will enable them to formulate crop regulation strategies for productivity enhancement.

THEORY

Block 1: Growth, development, assimilate partitioning and plant bio regulators

UNIT I: Stages of growth: Growth and development, definitions, components, photosynthetic productivity, different stages of growth, growth curves, growth analysis, morphogenesis in PSMA.

UNIT II: Growth pattern: in annual, semi-perennial and perennial crops, growth dimorphism, environmental impact on growth and development: effect of light, temperature, photoperiod.

UNIT III: Assimilate partitioning: Assimilate partitioning during growth and development, influence of water and mineral nutrition,

Block 2: Canopy management

UNIT I: Canopy management: Canopy management for conventional and high density planting pruning, training, chemicals, crop regulation for year round and off season production in PSMA

UNIT II: Plant bio regulators: plant bio regulators- auxins, gibberellins, cytokinins, ethylene, inhibitors and retardants, basic functions, biosynthesis and role in crop growth and development

Block 3: Developmental physiology and biochemistry

UNIT I: Vegetative phase: Developmental physiology and biochemistry during dormancy, bud break, juvenility

UNIT II: Flowering and fruit set

Physiology of flowering, photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism, pollination, fertilisation, fruit set, fruit drop, fruit growth, ripening, seed development in PSMA.

UNIT III: Growth and development process during stress: Growth and development process during stress, production of secondary metabolites, molecular and genetic approaches in growth and development.

PRACTICALS

1. Dormancy mechanisms in seeds, seed rhizomes
2. Techniques of growth analysis
3. Evaluation of photosynthetic efficiency under different environments
4. Technologies for crop regulation in cashew, coffee, cocoa etc
5. Root shoot studies, flower thinning, fruit thinning
6. Crop regulation for year round production
7. Use of growth regulators in PSMA crops

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Demonstrations
- Exposure visits

RESOURCES

- Afoakwa, E. O. 2016. *Cocoa Production and Processing Technology*. CRC Press
- Buchanan, B. W. Gruessam and Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*. John Wiley and Sons.
- E- manual on Advances in Cashew Production Technology. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
- Epstein ,E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. Wiley.
- Fosket, D. E. 1994. *Plant Growth and Development: A Molecular approach*. Academic Press.
- Leopold,A.C and Kriedermann, P.E. 1985. *Plant Growth and Development*. 3rd Ed. McGraw - Hill
- Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
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- Pillay. P. N. R. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668
- Ravindran, P.N. 2000. *Black pepper, Piper nigrum*. CRC press
- Ravindran, P.N. 2002. *Cardamom, the genus Elettaria*. CRC press
- Ravindran, P.N. 2003. *Cinnamon and cassia*. CRC press
- Ravindran, P.N. 2004. *Ginger, the genus Zingiber*. CRC press
- Ravindran, P.N. 2007. *Turmeric, the genus curcuma*. CRC press
- Ravindran, P.N. 2017. *The Encyclopedia of Herbs and Spices*. CABI
- Roberts, J. S. Downs and P. Parker. 2002. *Plant Growth Development*. In: *Plants* (L. Ridge, Ed.), pp. 221-274, Oxford University Pre
- Salisbury, F.B. and Ross, C.W. 1992. *Plant Physiology*. 4th Ed. Wadsworth Publ.
- Sera, T., Soccol, C.R., Pandey, A., Roussos, S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
- Sethuraj, M. R. and Mathew, N. T. 1992. *Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science)*. Elsevier Science.

PSM 510: BIOCHEMISTRY OF PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS (2+1)

WHY THIS COURSE?

Postharvest physiology and biochemistry of plantation, spice, medicinal and aromatic crops contributes immensely towards quality improvement in crude as well as processed products. Fundamental knowledge on biochemistry of various crops is also essential for formulating their management practices in the field. This course will impart theoretical as well as hands- on experience to the learner on the biochemistry of PSMA crops.

AIM OF THIS COURSE

To impart comprehensive knowledge on the biochemistry, production of primary and secondary metabolites and the extraction of bioactive principles from PSMA

The course is organized as follows:

S.No	Blocks	Units
1	Post harvest physiology	1.Physiological and biochemical changes 2.Contaminants
2	Value addition	1.Value added products 2.Quality standards
3	Extraction techniques	1.Extraction techniques 2.Plant tissue culture

LEARNING OUTCOME

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

➤ develop the technical know- how on postharvest biochemistry of plantation, spice, medicinal and aromatic crops.

THEORY

Block 1: Post harvest physiology

UNIT I: Physiological and biochemical changes: Maturity indices, changes during ripening, processing, factors affecting quality. Secondary metabolites and their biosynthetic pathways, factors affecting production of secondary metabolites

UNIT II: Contaminants: Adulterants, and substitutes, sources of contamination- microbial, heavy metal, pesticide residues in PSMA

Block 2: Value addition

UNIT I: Value added products: Fixed oils, essential oils, dyes, oleoresins, aroma chemicals and other value added products, their content, storage, medicinal and pharmacological properties, use in the food ,flavour perfumery and pharmaceutical industries

UNIT II: Quality standards: Quality standards of raw materials and finished products.

Block 3: Extraction techniques

UNIT I: Extraction methods: Basic and advanced extraction techniques in PSMA-S Soxhlet, SCFE, Membrane extraction. Chemical characterization-HPTLC, GCMS, LCMS, NMR UNIT II: Plant tissue culture: Plant tissue cultures in the industrial production of bioactiveplant metabolites. Cell suspension culture systems for large scale culturing of plant cells and production of secondary metabolites. Advantages of cell culture over conventionalextraction techniques.

PRACTICALS

1. Biochemical characterisation
2. Detection of adulterants and substitutes
3. Extraction and quantification of secondary metabolites
4. Chromatographic separation of the products
5. Quality assurance
6. Testing the product
7. Exposure visit to leading industries
8. Assessment of antimicrobial properties
9. *In vitro* production of secondary metabolites

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Demonstration
- Exposure visits

RESOURCES

- Afoakwa, E. O. 2016. *Cocoa Production and Processing Technology*. CRC Press
- Daniel, M. and Mammen, D. 2016. *Analytical methods for medicinal plants and economic botany*. Scientific publishers
- Das, K. 2013. *Essential oils and their applications*. New India Publishing Agency, New Delhi
- E- manual on Advances in Cashew Production Technology. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
- Hammon, J.M. and Yusibov, V. 2000. *Plant Biotechnology: New Products and application*. Springer-Verlag.
- Orhan, I. 2012. *Biotechnological Production of Plant Secondary Metabolites*. Bentham Science Publishers
- Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.
- Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea (2nd Revised Edition)*. Asia Pacific Business Press Inc.
- Parimelzhagan, T. 2013. *Turning plants into medicines: Novel approaches*. New India Publishing Agency, New Delhi
- Pillay, P. N. R. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668
- Ponnuswamiet al. 2018 *Medicinal Herbs and herbal cure*. Narendra Publishing House, New Delhi
- Raaman, N. 2006. *Phytochemical techniques*. New India Publishing Agency, New Delhi
- Raju, R. Wadekar. 2015. *Pharmacognosy and phytochemistry*, Event publishing house
- Ramawat, K.G. 2007. *Biotechnology: secondary metabolites : plants and microbes*. Science Publishers.
- Ranjalkandall. *Bioactive compounds and genomic study of medicinal plants*. LAMBERT Academic Publishing
- Sera, T., Soccol, C.R., Pandey, A., Roussos, S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.
- Sethuraj, M. R. and Mathew, N. T. 1992. *Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science)*. Elsevier Science.
- Shah, B and Seth, A.K. 2005. *Text book of Pharmacognosy and Phytochemistry*. Cbs Publishers and distributors, New Delhi.
- Shankar, S.J. 2018. *Comprehensive post harvest technology of flowers, medicinal and aromatic plants*. Narendra Publishing House, New Delhi
- Shukla, Y.M. 2009. *Plant secondary metabolites*. New India Publishing Agency, New Delhi

Syed Aftab Iqbal and Noor Ahmed Khan.1993.*Text book of Phytochemistry*. Discovery Publishing house Pvt. Ltd

Tiwari/Chandra (2018) *Antimicrobial properties of Medicinal plants*. Narendra Publishing House, New Delhi

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

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

PSM 511: BIODIVERSITY AND CONSERVATION OF PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS (2+1)

WHY THIS COURSE?

India is the homeland of several plantation, spice, medicinal and aromatic crops. Biodiversity conservation is considered as the primary step in protecting the gene pool available in these crops. Fundamental knowledge on centres of diversity, germplasm evaluation, documentation, data base management and cataloguing is most essential. This course will impart theoretical as well as hands-on experience to the learner on these areas.

AIM OF THIS COURSE:

To impart basic knowledge on natural as well as agro bio diversity, its value and conservation strategies with respect to PSMA's.

The course is organized as follows:

S.No	Blocks	Units
1	Plantation and spice crops	1. Biodiversity 2. Germplasm collection and quarantine 3. Documentation and cataloguing 4. National and international issues
2	Medicinal and aromatic crops	1. Biodiversity 2. Germplasm collection and quarantine 3. Documentation and cataloguing 4. National and international issues

LEARNING OUTCOME

After successful completion of this course, the students are expected to develop thorough understanding on biodiversity conservation of plantation, spice, medicinal and aromatic plants.

THEORY

Block 1: Plantation and Spice crops

UNIT I: Biodiversity: Biodiversity, issues and goals, centres of origin of Plantation and spice crops, primary and secondary centres of genetic diversity

UNIT II: Germplasm collection and quarantine: Exploration and germplasm collection, planning and logistics, exchange of germplasm, plant quarantine principles, regulations plant quarantine systems in India. Components of germplasm evaluation, descriptor lists. Conservation of genetics resources, Concept of base and active collections, long and short term storage of Plantation and spice crops, gene bank management

UNIT III: Documentation and cataloguing: Recent approaches and role of biotechnology in PGR conservation documentation and data base management, cataloguing gene bank information. Molecular markers in characterisation of plant genetic resources. GIS in biodiversity mapping

UNIT IV: National and international issues: Genetic resources management of Plantation and Spice crops in India and in International perspective. Utilization and achievements in major crops. Concepts of rarity, threat, endangerment and extinction in major plantation and spice crops. Bio diversity concerns, national and international regulations, conservation networks. Good collection practices, domestication, PPV and FRA and DUS testing. Geographical indication, Biodiversity act and biodiversity legislations.

Block II: Medicinal and aromatic crops

UNIT I: Biodiversity: Biodiversity, issues and goals, centres of origin of medicinal and aromatic crops, primary and secondary centres of genetic diversity

UNIT II: Germplasm collection and quarantine: Exploration and germplasm collection, planning and

logistics, exchange of germplasm, plant quarantine principles, regulations plant quarantine systems in India. Components of germplasm evaluation, descriptor lists. Conservation of genetics resources, Concept of base and active collections, long and short term storage of Plantation and spice crops, gene bank management

UNIT III: Documentation and cataloguing: Recent approaches and role of biotechnology in PGR conservation documentation and data base management, cataloguing gene bank information. Molecular markers in characterisation of plant genetic resources. GIS in biodiversity mapping

UNIT IV: National and international issues: Genetic resources management of Plantation and Spice crops in India and in International perspective. Utilization and achievements in major crops. Concepts of rarity, threat, endangerment and extinction in major plantation and spice crops. Bio diversity concerns, national and international regulations, conservation networks. Good collection practices, domestication, PPV and FRA and DUS testing. Geographical indication, Biodiversity act and biodiversity legislations

PRACTICALS

1. Collection and identification of different plantation, spice, medicinal and aromatic plants from natural sources
2. Preparation of herbarium
3. Botanical and phyto-chemical grouping of PSMAAs
4. Classification of PSMAAs based on plant parts used
5. Documentation of germplasm
6. Maintenance of passport data and other records,
7. Field explorations
8. Detection of adulterants and substitutes in PSMAAs
9. Ethno botanical studies in tribal areas.
10. Planning and layout of herbal gardens
11. Exposure visits to herbaria, herbal gardens and important organisations engaged in collection and utilization of PSMAAs

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Demonstrations
- Exposure visits

RESOURCES

Afoakwa, E. O. 2016. *Cocoa Production and Processing Technology*. CRC Press

Choudhari, A.B. *Megadiversity Conservation: Flora, Fauna and Medicinal Plants of India's hot spots*.

Devi, A.R; Sharangi, AB; Acharya, SK and Mishra GC 2017. *Coriander in Eastern India: The landraces and genetic diversity*. Krishi Sanskriti Publications. New Delhi. ISBN: 978-93-85822-48-3.

E- manual on Advances in Cashew Production Technology. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka

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

Khan, J. B. and Singh, G.P. 2012. *Biodiversity Management and Conservation* LAMBERT

Negi, S.S. *Biodiversity of India and its Conservation*.

Panda, H. 2002. *Medicinal Plants Cultivation and their Uses* . Asia Pacific Business Press.

Panda, H. 2005. *Aromatic Plants Cultivation ,Processing and Uses* . Asia Pacific Business Press

Panda, H. 2013. *The Complete Book on Cashew*. Asia Pacific Business Press Inc.

Panda, H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.

Panda, H. 2017. *Herbal and Aromatic Plants Cultivation, Processing, Utilisation and Applications*. Discovery publishing house, New Delhi

Pillay. P. N. R. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668

Ponnuswami *et al.* 2018. Medicinal Herbs and herbal cure. Narendra Publishing House, New Delhi

Ponnuswami *et al.* 2018. Spices. Narendra Publishing House, New Delhi

Pullaiah, T. 2011. *Biodiversity in India* Vol.5. Daya Publishing house

Rajak, R.C. and Rai, M.K. *Herbal Medicines, Biodiversity and Conservation strategies*. IBH.

Ramakrishnan, N. 2018. *Biodiversity in Indian Scenario*. Daya publishing house.

Sera, T., Soccol, C.R., Pandey, A., Roussos, S. *Coffee Biotechnology and Quality*. Springer, Dordrecht.

Sethuraj, M. R. and Mathew, N. T. 1992. *Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science)*. Elsevier Science.

Thirugnanakumar. 2018. *Genetic diversity and phenotypic stability in crop plants*. New India Publishing Agency, New Delhi

Trivedi, P.C. *Medicinal Plants: Utilization and Conservation*.

Ph. D. Syllabus

PSM 601: ADVANCES IN PRODUCTION OF PLANTATION AND SPICE CROPS(3+0)

WHY THIS COURSE?

Plantation and spice crops play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers. This course will impart knowledge to the learner on advanced scientific production technology of various plantation and spice crops in Indian perspectives. Hi-tech production technologies will be discussed in this course.

AIM OF THIS COURSE:

The course is designed to provide advanced crop production techniques of various plantation and spice crops grown in India.

The course is organized as follows:

S.No	Blocks	Units
1	Importance of Plantation and spice Crops	1. Area, production, productivity: Indian and world scenario
		2. Export potential
		3. Promotional programmes
2	Advanced agrotechniques	1. Varietal wealth and planting material production
		2. Mass multiplication techniques
		3. Hi-tech nursery techniques
		4. Impact of climate change
3	Harvest and post harvest management	1. Maturity indices and harvest
		2. Post-harvest management
		3. Quality standards

LEARNING OUTCOME

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

- be equipped with the latest research outcome in commercial cultivation of plantation and spice crops
- be able to start hi-tech plantation and spice crop based enterprises

THEORY

Block 1. Importance of Plantation and Spice Crops

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

UNIT II: Export potential: Export scenario, market opportunities and challenges in plantation and spice crops, global imports and exports, export of organic produce and products

UNIT III: 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

UNIT I: Varietal wealth and planting material production: Cultivars and improved varieties in plantation and spice crops, mass multiplication techniques, hi-tech nursery techniques.

UNIT II: 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

UNIT III: 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

UNIT I: 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

Unit II: Quality standards: Domestic and international standards, HACCP, BIS standards, domestic and export grades, modern packaging techniques, export protocols

Crops:

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

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Presentation of review papers and research articles
- Exposure visits to research centres, industries

RESOURCES

- Afoakwa, E.O. 2016. Cocoa Production and Processing Technology. CRC Press
- Agarwal, S., Divkarasastri, E.V., and Sharma, R.K. 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 of Spices, Aromatic, Medicinal and Plantation Crops. New India Publishing Agency, New Delhi.
- Chadha, K.L. 2001. Hand Book of Horticulture. ICAR.
- Chopra, V.L. and Peter, K.V. 2005. Handbook of Industrial Crops. Panama.
- Choudappa, P., Anitha, K., Rajesh, M.K., and Ramesh, S.V. 2017. Biotechnology of Plantation Crops. Daya Publishing House, New Delhi
- Choudappa, P., Niral, V., Jerard, B.A., 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, D.K., Karnataka.
- Harler, C.R. 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, K.V. 2007. Commercial Crops Technology. New India Publ. Agency. Marsh, A.C., Moss, M.K., and Murphy, E.W. 1977. Composition of Food Spices and Herbs, Raw, Processed and Prepared. Agric. Res. Serv. Hand Book 8-2. Washington DC.
- Nair, M.K, Bhaskararao, E.V.V., Nambiar, K.K.N., and Nambiar, M.C. 1979. Cashew. CPCRI, Kasaragod.
- Nybe, E.V, Mini Raj, N., and Peter, K.V. 2007. Spices. New India Publ. 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.
- Peter, K.V. 2001. Hand Book of Herbs and Spices. Vols. I-III. Woodhead Publ. Co., UK and CRC, USA.

Peter, K.V. 2002. Plantation Crops. National Book Trust.

Pillay, P.N.R. 1980. Handbook of Natural Rubber Production in India. Rubber Research Institute, Kottayam. pp.668

Ponnuswami et al. 2018. Spices. Narendra Publishing House, New Delhi

Pradeepkumar, T., Suma, B., Jyothibhaskar and Satheesan, K.N. 2007. Management of Horticultural Crops. Parts I, II. New India Publ. Agency.

Purseglove, J.W, Brown, E.G., Green, C.L., and Robbins, S.R.J. 1984. Spices. Vols. I, II. Longman.

Purseglove, J.W. 1968. Tropical Crops–Dicotyledons. Longman.

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.

Ravindran, P.N. 2003. Cinnamon and cassia. CRC press

Ravindran, P.N. 2004. Ginger, the genus Zingiber. CRC press

Ravindran, P.N. 2007. Turmeric, the genus curcuma. CRC press, Medicinal and Aromatic Plants - Industrial Profiles. Routledge, UK.

Ravindran, P.N. 2001. Monograph on Black Pepper. CRC Press.

Ravindran, P.N. 2017. The Encyclopedia of Herbs and Spices. CABI

Ravindran, P.N. and Madhusoodanan, K.J. 2002. Cardamom, the Genus Elettaria. CRC press.

Sera, T., Soccol, C.R., Pandey, A., and Roussos, S. Coffee Biotechnology and Quality. Springer, Dordrecht.

Sethuraj, M.R. and Mathew, N.T. 1992. Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science). Elsevier Science.

Shanmugavelu, K.G., Kumar, N., and Peter, K.V. 2002. Production Technology of Spices and Plantation Crops. Agrobios.

Sharangi, A. B. and Acharya, S.K. 2008. *Quality management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2

Sharangi, A. B. and Datta, S. 2015. *Value Addition of Horticultural crops: Recent trends and Future directions*. SPRINGER; ISBN: 978-81-322-2261-3.

Sharangi, A.B, Datta, S., and Deb, P. 2018. Spices: Agrotechniques for quality produce, April, Academic Press (Tylor and Francis Groups), New Jersey, USA.

Sharangi, A.B. 2018. Indian Spices: The legacy, production and processing of India's treasured export. Springer International publishing. AG, Part of Springer Nature, 2018, Cham, Switzerland.

Srivastava, H.C, Vatsaya., and Menon, K.K.G. 1986. Plantation Crops–Opportunities and Constraints. Oxford and IBH.

Swain, S.C. 2018. Precision Farming in Horticulture: Approaches and strategies. Narendra Publishing House, New Delhi.

Thampan, P.K. 1981. Hand Book of Coconut Palm. Oxford and IBH.

Varmudy, V. 2001. Marketing of Spices. Daya Publ. House.

Winton, A.L. and Winton, K.B. 1931. The Structure and Composition of Food. John Wiley and Sons.

Yagna Narayan Ayer, A.K. 1960. Cultivation of Cloves in India. ICAR.

PSM 602: ADVANCES IN PRODUCTION OF MEDICINAL AND AROMATIC CROPS (3+0)

WHY THIS COURSE?

Medicinal and aromatic crops play an important role in the national economy of India. They also cater to the primary health care needs of a large section of people. This course will impart knowledge to the learner on advanced scientific production technology of various medicinal and aromatic crops in Indian perspectives.

AIM OF THIS COURSE:

The course is designed to provide latest developments and trends in the production technology of various medicinal and aromatic crops grown in India.

The course is organized as follows:

S.No	Blocks	Units
1	Importance of Medicinal and Aromatic Crops	1. Biodiversity of medicinal and aromatic crops
		2. Area, production, productivity statistics
		3. Export potential
2	Advanced Agrotechniques	1. Domestication studies
		2. Varietal wealth and planting material production
		3. Agro techniques
		4. Impact of climate change
3	Harvest and post Harvest Management	1. Maturity indices and harvest
		2. Modern methods of extraction of MAPs
		3. Quality standards

LEARNING OUTCOME

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

- be equipped with the latest research outcome in commercial cultivation of medicinal and aromatic crops
- be able to start hi-tech medicinal and aromatic crop based enterprises

THEORY

Block 1. Importance of Medicinal and Aromatic Crops

UNIT I: Biodiversity of medicinal and aromatic crops (MAPs): Biodiversity of MAPs, conservation networks, global initiatives on medicinal plants conservation and development, World history on usage of MAPs, preference to natural products. Indian traditional wisdom and heritage, Indian herbal wealth, documentations, databases, scientific validation.

UNIT II: 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.

UNIT III: 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 agro-techniques

UNIT I: 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

UNIT II: Varietal wealth and planting material production: Cultivars and improved varieties in

medicinal and aromatic crops, mass multiplication techniques, micropropagation, hi-tech nursery techniques,

UNIT III: Agro techniques: Advanced research in the field of growth and development, nutrition and irrigation requirements, inter culture, mulching, weed control.

Precision farming techniques, HDP systems, fertigation, chemical regulation of crop productivity, protected cultivation of high value crops, hydroponics, aeroponics, application of nanotechnology, nano-fertilizers, nano-pesticides, robotics.

UNIT IV: 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 post harvest management

UNIT I: Maturity indices and harvest: Influence of pre and post harvest factors on quality of medicinal and aromatic crops, pre and post harvest management techniques for improving quality, good manufacturing practices in herbal sector

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

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

Crops

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

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

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignmentw (Reading/Writing)
- Presentation of review papers and research articles
- Exposure visits to research centres, industries

RESOURCES

Dharamvir, H. 2007. Bioactive Medicinal Plants. Gene Tech Books.

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PSM 603: RECENT BREEDING APPROACHES IN PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS
3+0

WHY THIS COURSE?

Plantation, spice medicinal and aromatic crops (PSMA) play an important role in the national economy of India. These crops also provide livelihood security to a large section of farmers and cater to the primary health care needs of a large section of people. This course will impart knowledge to the learner on the advanced breeding approaches followed in important PSMA crops in Indian perspectives.

AIM OF THIS COURSE:

The course is designed to provide knowledge on modern approaches in the breeding of various PSMA crops grown in India.

The course is organized as follows:

S.No	Blocks	Units
1	Plantation crops	1. Genetic resources
		2. Breeding methods
		3. Breeding achievements
2	Spice crops	1. Genetic resources
		2. Breeding methods
		3. Breeding achievements
3	Medicinal and Aromatic crops	1. Genetic resources
		2. Breeding methods
		3. Breeding achievements

LEARNING OUTCOME

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

- be equipped with the latest research outcome in crop improvement of PSMA crops
- be able to start hi-tech PSMA crop based seed/planting material production programmes

THEORY

Block 1. Plantation Crops

UNIT I: 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

UNIT II: 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.

UNIT III: Breeding achievements: Breeding objectives, ideotype breeding, breeding problems and achievements in Plantation crops.

Block 2. Spice crops

UNIT I: 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

UNIT II: 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.

UNIT III: Breeding achievements: Breeding objectives, ideotype breeding, breeding problems and achievements in Spice crops.

Block 3. Medicinal and aromatic crops

UNIT I: 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.

UNIT II: 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

UNIT III: Breeding achievements: Specific breeding objectives in medicinal and aromatic crops, ideotype breeding, breeding problems and achievements in medicinal and aromatic crops.

Crops

A. Plantation crops: Coconut, Arecanut, Oil palm, Cashew, Coffee, Tea, Cocoa, Rubber

B. Spice crops: Black pepper, Cardamom, Ginger, Turmeric, Nutmeg, Cinnamon, Clove, Garcinia, Coriander, Cumin, Fennel, Fenugreek, Ajwain, Dill.

C. Medicinal crops: Senna, Periwinkle, Aswagandha, Isabgol, Sarpagandha, Poppy, Glory lily, Medicinal coleus, *Mucuna pruriens*, Ocimum, *Centella asiatica*, *Bacopa monnieri*, *Andrographis paniculata*, *Aloe vera*, *Phyllanthus amarus*, Eucalyptus, Bael, Henbane.

D. Aromatic crops: Lemon grass, Palmarosa, Citronella, Vetiver, Mint, Sweet basil, Lavender, Geranium, Patchouli, Artemisia, Rosemary, Thyme, Sage, Marjoram, Fever few.

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Presentation of review papers and research articles
- Exposure visits to research centres, PSMA crop based industries

RESOURCES

Afoakwa, E.O. 2016. Cocoa Production and Processing Technology. CRC Press.

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Atal, C. and Kapoor, V. 1992. Cultivation and Utilization of Medicinal and Aromatic Crops. CSIR.

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Marsh, A.C., Moss, M.K., and Murphy, E.W. 1977. Composition of Food Spices and Herbs, Raw, Processed and Prepared. Agric. Res. Serv. Hand Book 8-2. Washinton DC.

Nair, M.K., Bhaskararao, E.V.V., Nambiar, K.K.N., and Nambiar, M.C. 1979. Cashew. CPCRI, Kasaragod.

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Ponnuswami, V. et al. 2018. Blossom biology of Horticultural crops. Narendra PublishingHouse, New Delhi.

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Prajapati, N.D., Purohit, S.S, Sharma, A.K., and Kumar, T. 2006. A Hand book of Medicinal Plants. Agro Bios.

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Ravindran, P.N. 2007. Turmeric, the genus curcuma. CRC press. Medicinal and Aromatic Plants - Industrial Profiles. Routledge, UK.

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Sera T., Soccol C.R., and Pandey A., Roussos S. Coffee Biotechnology and Quality. Springer, Dordrecht.

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Sharangi, A.B., Datta, S., and Deb, P. 2018. Spices:Agrotechniques for quality produce, April Academic Press (Tylor and Francis Groups), New Jersey, USA

Srivastava, H.C, Vatsaya., and Menon, K.K.G. 1986. Plantation Crops–Opportunities and Constraints.

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Swain, S.C. 2018. Precision farming in Horticulture: Approaches and strategies. Narendra Publishing House, New Delhi.

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Thampan, P.K. 1981. Hand Book of Coconut Palm. Oxford and IBH.

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Warrier, P.K., Nambiar, V.P.K., and Ramankutty, C. 2007. Indian Medicinal Plants, a compendium of 500 species. University Press (India) Private Ltd.

Winton, A.L. and Winton, K.B. 1931. The Structure and Composition of Food. John Wiley and Sons.

Yagna Narayan Ayer, A.K. 1960. Cultivation of Cloves in India. ICAR.

PSM 604: ADVANCES IN LABORATORY TECHNIQUES FOR PSMA CROPS (1+2)

WHY THIS COURSE?

Plantation, spice, medicinal and aromatic crops demand specific post harvest management and value addition. At each step it has to undergo quality assessment using modern equipment and machinery. Export standards are also based on stringent quality parameters. This course is designed to make the learner well versed with modern analytical methods, instruments and machinery used in quality analyses.

AIM OF THE COURSE:

To equip the students with the latest laboratory techniques required for assessing the quality of PSMA crops. The course is organised as follows

S.No.	Blocks	Units
1	Plantation Crops	1. Physiological and biochemical changes
		2. Contaminants
		3. Value addition
2	Spice Crops	1. Physiological and biochemical changes
		2. Contaminants
		3. Value addition
3	Medicinal and Aromatic Crops	1.Secondary metabolites and their biosynthetic pathways
		2. Contaminants
		3. Value addition

LEARNING OUTCOME

After completion of this course, the student will be equipped in

- the modern analytical methods of biochemistry
- handling of equipments and machinery used in biotechnology, processing and value addition

THEORY

Block 1. Plantation Crops

UNIT I: Physiological and biochemical changes: Physiological and biochemical changes during maturity and ripening including post harvest changes. Factors influencing quality

UNIT II: Contaminants: Adulterants, substitutes, sources of contamination: microbial, heavy metal, pesticide residues

UNIT III: Value addition: Fixed oils, value added products, grading, storage, transportation

Block 2. Spice Crops

UNIT I: Physiological and biochemical changes: Physiological and biochemical changes during maturity and ripening including Post harvest changes. Factors influencing quality

UNIT II: Contaminants: Adulterants, substitutes, sources of contamination: microbial, heavy metal, pesticide residues

UNIT III: Value addition: Fixed oils, essential oils, value added products, grading, storage, transportation.

Block 3. Medicinal and aromatic crops

UNIT I: Secondary metabolites and their biosynthetic pathways, factors affecting production of secondary metabolites, changes during maturity, harvesting and processing

UNIT II: Contaminants: Adulterants, substitutes, contamination: microbial, heavy metal, pesticide residues

UNIT III: Value addition: Fixed oils, essential oils, oleoresins, concretes, absolutes, dyes, natural colours, aroma chemicals, grading, storage, transportation. Quality standards of raw materials and finished products

PRACTICAL

1. Sampling techniques in PSMA crops or their parts
2. Solvent extraction of spices and medicinal plants
3. Detection of adulterants and substitutes
4. Extraction of secondary metabolites from medicinal crops
5. Qualitative analyses of secondary metabolites
6. Quantitative estimation of secondary metabolites
7. Preparation of plant extracts
8. Chromatographic separation of extracts
9. Thin layer chromatography
10. Soxhlet extraction
11. Super critical fluid extraction
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. Bioassay and High Throughput Screening.
19. Techniques for assessment of antimicrobial property
20. Techniques for assessment of antioxidant property, pesticide residue analyses
21. Determination of heavy metals by flame photometry
22. Plant tissue cultures in the industrial production of bioactive plant metabolites
23. Exposure visit to leading medicinal and aromatic industries, accredited quality controllabs.

RESOURCES

- 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, J.M. and Yusibov, V. 2000. Plant Biotechnology: New Products and application. Springer-Verlag.
- Orhan, I. 2012. Biotechnological Production of Plant Secondary Metabolites. Bentham Science Publishers.
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- Shankar, S.J. 2018. Comprehensive post harvest technology of flowers, medicinal and aromatic plants. Narendra Publishing House, New Delhi.
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- Parimelzhagan, T. 2013. Turning plants into medicines: Novel approaches. New India Publishing Agency, New Delhi.
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- Waghulkar, V.M. 2012. Quality assurance techniques in pharmaceuticals. New India Publishing Agency, New Delhi.

PSM 605: BIOTECHNOLOGICAL APPROACHES IN PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS (3 +0)

WHY THIS COURSE?

Tools of biotechnology are widely used in crop improvement, crop management, crop protection and post harvest management of PSMA crops. This course is designed to impart knowledge on advanced biotechnological tools used in various spheres of plantation, spices, medicinal and aromatic crops.

AIM OF THE COURSE:

The main objective of the course is to impart to the learner, knowledge on advanced biotechnological tools used in various spheres of plantation, spices, medicinal and aromatic crops.

The course is organized as follows

S.No	Blocks	Units
1	Plantation Crops	1. <i>In vitro</i> mass multiplication techniques
		2. <i>In vitro</i> breeding
		3. Transgenic crops
2	Spice Crops	1. <i>In vitro</i> mass multiplication techniques
		2. <i>In vitro</i> breeding
		3. Transgenic crops
3	Medicinal and Aromatic Crops	1. <i>In vitro</i> mass multiplication techniques
		2. <i>In vitro</i> breeding
		3. Transgenic crops
		4. <i>In vitro</i> production of secondary metabolites

OUTCOME OF THE COURSE

The learner is expected to be

- acquainted with the applications of biotechnology in PSMA crops
- able to start modern labs based on biotechnology in PSMA crops

THEORY

Block 1. Plantation Crops

UNIT I: *In vitro* mass multiplication techniques: *In vitro* conservation of plantation crops, direct and indirect organogenesis, micro grafting, hardening techniques

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

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

Block 2. Spice Crops

UNIT I: *In vitro* mass multiplication techniques: *In vitro* conservation of spice crops. direct and indirect organogenesis, micro grafting, hardening techniques, production of microrhizomes

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

UNIT III: Transgenic crops: Recombinant DNA methodology, gene transfer methods, tools, methods,

applications of rDNA technology. Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements, problems and future thrusts

Block 3. Medicinal and Aromatic Crops

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

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

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

UNIT IV: *In vitro* production of secondary metabolites: *Invitro* production and characterization of secondary metabolites, bioreactors.

CROPS

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

RESOURCES

Afoakwa, E.O. 2016. Cocoa Production and Processing Technology. CRC Press.

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PSM 606: ABIOTIC STRESS MANGEMENT IN PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS (2+1)

WHY THIS COURSE?

Global climate is undergoing drastic changes and crops find it difficult to adapt to the changed environments. Abiotic stress due to temperature, water, salts, radiations, nutrients, pollutants etc. affects the growth, physiology, yield and quality attributes of PSMA crops. This course is designed for the learner to understand the influence of these abiotic stress factors on PSMA crops.

AIM OF THE COURSE:

The course aims to impart knowledge on the influence of abiotic stress factors on growth, physiology, yield and quality attributes of PSMA crops along with advanced approaches in the management of these stresses.

The course is organized as follows

S.No	Blocks	Units
1	Abiotic Stress	1. Temperature and water stress
		2. Stress due to soil conditions and salt
		3. Pollution stress
		4. Other stresses
2	Climate Change	1. Contributing factors
		2. Carbon trading
		3. Impact of climate change on PSMA crops
3	Climate Resilient Technologies	1. Varieties
		2. Climate resilient technologies
		3. Waste management

OUTCOME OF THE COURSE

The learner is expected to get empowered on

- the impact of abiotic stress on PSMA crop production
- the mitigation measures to be adopted for sustaining PSMA crop production

THEORY

Block 1. Abiotic Stress

Definition, soil conditions (salinity, alkalinity, ion toxicity, fertilizer toxicity, etc.), salt stress

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

UNIT II: Stress due to soil conditions and salts: Alkalinity, salinity, iron toxicity, fertilizer toxicity symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality

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

UNIT IV: Other stresses: Stress due to radiation, wind, nutrients. symptoms, mechanisms governing tolerance, associated physiological and biochemical factors, impact on PSMA crops and produce, changes in phenology and quality

Block 2. Climate change

UNIT I: Contributing factors: Introduction to climate change, factors contributing to climate change, change in temperature, rainfall, humidity, rise in the atmospheric CO₂ levels, tropospheric ozone levels, extreme

climatic events

UNIT II: Carbon trading: Global warming, carbon trading, role of green housegases, impact on productivity of PSMA crops. Clean development mechanism

UNIT III: Impact of climate change on PSMA crops: Plantation crops, Spice crops, Medicinal and aromatic crops

Block 3. Climate resilient technologies

UNIT I: Varieties: Plantation crops, Spice crops, Medicinal and aromatic crops,

UNIT II: Climate resilient technologies: Plantation crops, Spice crops, Medicinal and aromatic crops.

UNIT III: Waste management: Alternate farming systems, Zero waste management, Microbial waste management

PRACTICAL

1. Analysis of plant stress factors
2. Relative water content
3. Chlorophyll stability index
4. Plant waxes
5. Stomatal diffusive resistance
6. Transpiration
7. Photosynthetic rates
8. Calculation of water use efficiency and growth rates
9. Identifying abiotic stress symptoms and injuries
10. Use of antitranspirants
11. Managing nutrient stress
12. Stress management by hormones
13. Screening for abiotic stress tolerance.
14. Weather data analyses and quantification of climate change
15. Cropping pattern changes due to climate extremities
16. Phenological and quality changes in PSMA
17. Pesticide residue analysis in PSMA.

RESOURCES

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Ahmad, Parvaiz, M.N.V. and Prasad, 2012. Abiotic Stress Responses in Plants Metabolism, Productivity and Sustainability. Springer.

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Sethuraj, M.R. and Mathew, N.T. 1992. Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science). Elsevier Science.

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www.plantsress.com

PSM 607: ORGANIC SPICE AND PLANTATION CROPS PRODUCTION (2+1)

WHY THIS COURSE?

A shift to organic agriculture is happening in different parts of the world. Demand for organic plantation and spice crops is also increasing globally. This course is designed to give comprehensive knowledge on scientific organic farming technology in plantation and spice crops.

AIM OF THE COURSE:

To impart knowledge on principles, concepts, techniques and certification procedures of organic farming in spice and plantation crops

The course is organized as follows

S. No	Blocks	Units
1	Concepts of Organic Farming	1. Importance
		2. Organic conversion plan
		3. Organic farming systems
2	Organic Production Technologies	1. Plantation crops
		2. Major spices
		3. Minor spices
3	Certification and Quality Control	1. Accreditation
		2. Organic standards
		3. Quality control

OUTCOME OF THE COURSE

The learner is expected to get empowered on

- the organic farming techniques in Spice and Plantation crops
- the organic certification procedures in Spice and Plantation crops

THEORY

Block 1. Concepts of Organic Farming

UNIT I: 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

UNIT II: 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

UNIT III: Organic Farming Systems: Natural farming, permaculture, biodynamic farming, Zero budget farming, Homa farming, EM technology

Block 2. Organic Production Technology

UNIT I: Plantation crops: Coconut, Coffee, Cocoa, Tea

UNIT II: Major Spices: Black pepper, Cardamom, Ginger, Turmeric, Vanilla UNIT III: Seed spices: Coriander, Cumin, Fennel, Fenugreek

Block 3. Certification and Quality Control

UNIT I: Accreditation: Accreditation agencies, certification agencies, procedure of certification, types of certification

UNIT II: Organic standards: Domestic and international standards, NPOP, IFOAM, CODEX, HACCP standards

UNIT III: Quality control: Participatory Guarantee System (PGS) in quality control, quality control for organic products

PRACTICAL

1. Enrichment of composts
 - a. Biofertilizers
 - b. Bio control agents
2. Biodynamic preparations
3. Zero- budget preparations
4. Biopesticides
5. AMF in organic production
6. Waste management techniques
7. Exposure visits to organic fields, certification and marketing centers.

RESOURCES

- Afoakwa, E.O. 2016. Cocoa Production and Processing Technology. CRC Press.
- Dahama, A.K. 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.
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- Panda, H. 2016. The Complete Book on Cultivation and Manufacture of Tea (2nd Revised Edition). Asia Pacific Business Press Inc.
- Parthasarthy, V.A., Kandianan, V., and Srinivasan, V. 2008. Organic Spices. New India Publ. Agency.
- Pradeepkumar, T., Suma, B., Jyothibhaskar, and Satheesan, K.N. 2008. Management of Horticultural Crops. New India Publ. Agency.
- Sera, T., Soccol, C.R., Pandey, A., 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.

PSM 608: MARKETING AND TRADE OF PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS (2+1)

WHY THIS COURSE?

Marketing and trade are two important aspects in the domestic as well as international movement of PSMA crops. Instability in the price structure as well as demand of various plantation and spice crops often puts the farmers and enterpruners at risk. This course is designed to impart in the learner a deeper understanding on marketing and trade in raw materials and value added products of PSMA's crops both at the domestic and international level.

AIM OF THE COURSE:

This course is designed to impart in the learner a deeper understanding on marketing and trade in raw materials and value added products of PSMA's crops both at the domestic and international level.

The course is organized as follows

S.No	Blocks	Units
1	Importance of Marketing and Trade	1. Market opportunities
		2. Marketing strategies
2	Marketing Channels	1. Market organisations
		2. Value chain management and total quality management
3	Entrepreneurship Development	1. Decision making
		2. Price structure

OUTCOME OF THE COURSE

The learner is expected to get empowered on

- the marketing and trade opportunities and channels in PSMA crops
- the entrepreneurship development and value chain in PSMA crops
- decision support and pricing system in PSMA crops

THEORY

Block 1. Importance of marketing and trade

UNIT I: 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 PSMA's at the national and international level, Marketing and trade in raw materials and value added products

UNIT II: 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

Block 2. Marketing Channels

UNIT I: Market organizations: Marketing co-operatives including tribal co-operatives, public private partnerships (PPP), Farmer Producer Companies (FPC) and Farmer Producer Organisations (FPOs).

UNIT II: 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

Block 3. Entrepreneurship development

UNIT I: 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 PSMA's

UNIT II: 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 organic products

PRACTICAL

1. Study of requirement of various raw materials by the plantation, spice and ayurveda industries
2. Demand supply analysis of various PSMA crops.
3. Exposure visit to trading centres, exporters, ware houses, value addition units etc.
4. Study of FPOs and FPCs in various crops.
5. Preparation and evaluation of projects
6. Documentation of case studies

RESOURCES

Afoakwa, E. O. 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.

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Panda, H. 2013. The Complete Book on Cashew. Asia Pacific Business Press Inc.

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Pillay, P.N.R. 1980. Handbook of natural rubber production in India. Rubber Research Institute, Kottayam. pp.668.

Sera, T., Soccol, C.R., Pandey, A., Roussos, S. Coffee Biotechnology and Quality. Springer, Dordrecht.

Sethuraj, M.R. and Mathew, N.T. 1992. Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science). Elsevier Science.

Tyagi, S.K. 2015. Spices, Plantation Crops, Medicinal and Aromatic plants-a hand book. New India Publishing Agency.

Varmudi, 2001. Marketing of Spices. Daya publishing house.

Ved, D. K. and Goraya, G.S. 2007. Demand and Supply of Medicinal Plants in India. NMPB, New Delhi, FRLHT, Bangalore.

SUGGESTED JOURNALS

S.No	Title	ISSN
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 environment 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 Seed Spices	
15	International Journal of tea Science	0972-544X
16	Journal of applied Horticulture	0972-1045
17	Journal of Herbs, Spices, and Medicinal Plants	1540-3580
18	Journal of medicinal and aromatic plant sciences	0253-7125
19	Journal of Medicinal food	1557-7600
20	Journal of Medicinal Plant research	1996-0875
21	Journal of Medicinal Plant studies	2320-3862
22	Journal of Plantation crops	2454-8480
23	Journal of spices and aromatic crops	0971-3328
24	Medicinal Plants: International Journal of Phytomedicines and Related	0975-4261
25	Polycyclic Aromatic Compounds	1040-6638
26	Progressive Horticulture	2249-5258
27	Rubber Science (Natural Rubber Research)	2524-3993
28	Spice India	0970-5805
29	The Asian Journal of Horticulture	0973-4767

POST HARVEST MANAGEMENT (PHM)

M.Sc. (Hort.) Post Harvest Management

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 Horticulture	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

Ph. D. (Hort.) Post Harvest Management

Code	Course title	Credits 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	1+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

M.Sc. Syllabus

PHM 501:POST HARVEST MANAGEMENT OF HORTICULTURAL PRODUCE (2+1)

WHY THIS COURSE?

Fruits and vegetables are perishable crops that suffer great losses both in quantity and quality after harvest. These produce require integrated approach to arrest their spoilage and overcome the present day challenges that assimilates millions of tons annually. Lack of postharvest awareness and absence of sufficient and functioning equipment in the postharvest chain result in serious postharvest losses in developing countries. Clear and comprehensive understanding of postharvest deteriorative factors is necessary to overcome these challenges. Pre and postharvest management such as good cultural practices, use of improved varieties, good handling practices pre and postharvest, temperature and relative humidity management, storage atmosphere management, use of permitted chemicals, design of appropriate packaging materials and storage structures are some of the control measures use in reducing postharvest losses. Hence this customized course

AIM OF THIS COURSE:

To impart comprehensive knowledge on management of horticultural produce thus extending the post-harvest life of the produce by various treatments.

The course is organized as follows

S.No	Blocks	Units
1	Postharvest management of horticultural produce	1. Importance and scope
		2. Regulation of ripening
		3. Treatments for extending shelf life
		4. Handling system and marketing of horticultural crops

LEARNING OUTCOMES:

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

- Regulation of ripening by use of chemicals and growth regulators
- Pre and Postharvest treatments for extending storage life/vase life
- Standards and specifications for fresh produce

THEORY:

Block 1: Postharvest Management of Horticultural Produce

UNIT-I: History, Importance and scope of Postharvest technology of horticultural produce. Nature and structure of horticultural produce. Pre and Postharvest losses and their causes.

UNIT-II: Climacteric and non-climacteric fruits. Regulation of ripening by use of chemicals and growth regulators. Control of sprouting, rooting and discoloration in vegetables.

UNIT-III: Maturity indices for harvest. Harvesting and harvesting tools. Curing in roots and tubers. Prepackage Operation: Precooling, washing, sorting, grading of horticultural perishables for local markets and export. Postharvest handling of spices, plantation crops, medicinal and aromatic plants. Equipments for washing, sizing, grading.

UNIT-IV: Pre and Postharvest treatments for extending storage life/vase life. VHT, irradiation treatment, skin coating, degreening etc. Prepackaging, Packaging techniques for local market and export. Standards and specifications for fresh produce.

UNIT-V : Postharvest handling system for horticulture crops of regional importance. Principles of transport, modes of transportation, types of vehicles and transit requirements for different horticultural produce. Marketing: Factors influencing marketing of perishable crops, marketing systems and organizations.

PRACTICALS:

1. Study of maturity indices for harvest of fruits, vegetables, spices and plantation crops.
2. Protective skin coating with wax emulsion and pre and Postharvest treatment with fungicides, chemicals and growth regulators to extend the shelf life of fruits and vegetables.
3. Prepackaging of perishables
4. Extension of vase life of cut flowers by use of chemicals and growth regulators.
5. Control of sprouting of potato and onion by using growth regulators.
6. Study of modern harvesting, sorting and grading equipments.
7. Study of effect of pre-cooling on shelf-life and quality of fresh fruits, vegetables and flowers.
8. Visit to packaging centers.
9. Visit to local markets, cooperative organizations, super markets dealing with marketing of Perishables.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentation
- Group Work /seminars

RESOURCES:

Thompson A. K. (Ed.) (2014) Fruit and Vegetables: Harvesting, Handling and Storage (Vol. 1 & 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.

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.

Sudheer K.P., Indira V (2007) Postharvest Technology of Horticultural Crops, Peter K.V. (Ed.), New India Publishing Agency, ISBN 9788189422431.

Sunil Pareek (Ed.) (2016) Postharvest Ripening Physiology of Crops, CRC Press, ISBN 9781498703802.

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.

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.

Bhattacharjee S. K, and Dee L. C. (2005). Postharvest technology of flowers and ornamental plants. Pointer publishers, Jaipur.

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

FAO.2007. Handling and Preservation of Fruits and Vegetables by Combined methods for Rural Areas- Technical Manual. FAO Agr.Ser.Bull., 149.

Kader A. A. 1992. Postharvest technology of horticultural crops. 2nd ed university of California.

Pruthi J. S. 2001 (Reprint). Major spices of India crop management and Postharvest technology. ICAR, New Delhi

Stawley J. Kays. 1998. Postharvest physiology of perishable plant products. CBS publishers. 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>

PHM 502: POST HARVEST PHYSIOLOGY AND BIOCHEMISTRY OF PERISHABLES (2+1)

WHY THIS COURSE?

Immediately after harvesting, vegetables and fruits are subjected to the active processes of degradation. Numerous physiological and biochemical processes continuously change the original composition of the crop until which decrease the shelf life of the produce. Postharvest physiology is the scientific study of the physiology of living plant tissues after picking. It is very much necessary to learn about it as has direct applications to postharvest handling in establishing the storage and transport conditions that prolong shelf life. Hence this customized course.

AIM OF THIS COURSE

To impart comprehensive knowledge on physiology of horticultural produce after harvest and to understand different physiological processes like respiration ripening

The course is organized as follows:

S.No	Blocks	Units
1	Biochemistry of perishable	1. Structure and composition of horticultural produce
		2. Biochemical Changes after harvest
2	Postharvest physiology of perishables	1. Maturity, Ripening and respiration
		2. Respiratory climacteric and transpiration
		3. Factors affecting shelf-life

LEARNING OUTCOMES

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

THEORY

Block 1: Biochemistry of Perishables

UNIT I: Introduction, biochemical structure and composition of fruits, vegetables and ornamentals.

UNIT-II: Biochemical changes during development and ripening. Structural Deterioration of the Produce-cell wall degradation, change in membrane lipid.: Biosynthesis of ethylene and its regulation. Ethylene action and ripening processes, its perception-action and regulation

Block 2: Postharvest physiology of perishables

UNIT-I: Determining Maturity and maturity indices. Ripening processes: events of ripening and factors affecting them

UNIT-II: Physiology of preharvest and postharvest; factors affecting shelf-life and quality of fruits, vegetables and ornamentals.

UNIT-III: Respiration: respiratory climacteric, its significance. Transpiration and water stress during postharvest. Postharvest oxidative stress: active oxygen species, AOS generation, physiological effects on horticultural commodity, control of oxidative injury.

PRACTICALS

1. Determination of physical parameters like specific gravity ,fruit firmness etc.,
2. Determination of physiological loss in weight.
3. Determination of chemical constituents like sugar, starch, pigments, Vitamin C, acidity during maturation and ripening in fruits/vegetables.

4. Estimation of ethylene evolved from ripening fruits.
5. Delay/Hastening of ripening by ethylene treatments.
6. Determination of firmness, TSS, moisture, Titratable acid, sugar, protein, starch, fats, chlorophyll, carotene, anthocyanin, phenols and tannins.
7. Measurement of respiration and ethylene evaluation.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentations
- Group Work

RESOURCES:

Wills R. B. H. and Golding, J. (2017) *Advances in Postharvest Fruit and Vegetable Technology*, CRC Press, ISBN 9781138894051.

Sunil Pareek (Ed.) (2016) *Postharvest Ripening Physiology of Crops*, CRC Press, ISBN 9781498703802.

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.

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.

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

D. Mark Hodges (2003) *Postharvest Oxidative Stress in Horticultural Crops*, 1st Edition, ISBN 9781560229636

Thompson, A.K. 1995 *Post harvest Technology of fruits and vegetables*. Blackwell Sciences

Chadha K.L. and Pal R.K. (2015) *Managing postharvest quality and losses in horticultural crops*. Vol-1: General Issues, 1-231p Astral International (P) Ltd., New Delhi

Chadha K.L. and Pal R.K. (2015) *Managing postharvest quality and losses in horticultural crops*. Vol-2: Fruit Crops, 253-561p Astral International (P) Ltd., New Delhi

Chadha K.L. and Pal R.K. (2015) *Managing postharvest quality and losses in horticultural crops*. Vol-3: Vegetables, Flowers and Plantation Crops, 581-727p Astral International (P) Ltd., New Delhi

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>

PHM 503: PACKAGING AND STORAGE OFFRESH HORTICULTURAL PRODUCE (1+1)

WHY THIS COURSE?

Being a potential source of minerals, vitamins and proteins and carbohydrates, horticultural commodities play an important role in the health and nutritional security of the people. Proper packaging and storage will utilize market surplus during glut season and thus give boost to the food industry. Horticultural produce is highly perishable particularly under tropical conditions of India. The spoilage of these commodities can be reduced to a large extent by this storage technology. Hence this customized course

AIM OF THIS COURSE:

To acquaint with the different storage systems and packaging systems for perishable horticultural produce.

The course is organized as follows:

S.No	Blocks	Units
1	Storage systems	1. Importance of storage
		2. Different methods of storage
		3. Modified methods of storage
2	Packaging	1. Importance of packaging and packaging methods
		2. New technologies in packaging

LEARNING OUTCOMES

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

- Importance of storage of horticultural produce
- Different methods of storage
- Importance of packaging for fresh horticultural produce
- Different methods of packaging

THEORY:

Block 1: Storage Systems

UNIT-I: Importance of storage of horticultural produce, present status and future scope. Principles and methods of storage – field storage structures and designs for bulk storage of horticultural produce- onion and potato etc.. Evaporative cool chambers. Physiological changes during storage.

UNIT-II: Refrigerated storage - principles of refrigeration, types of refrigerants, refrigeration equipments. Cold storage rooms - Calculation of refrigeration load. Storage requirements of different fruits, vegetables, flowers. Storage disorder symptoms and control.

UNIT-III: Controlled or modified atmosphere (CA/MA) storage - principles, uses, structures and equipments, methods and requirements. Effect of CA storage on the physiology of stored produce. Hypobaric storage- principle, uses, and requirements. Storage disorders.

Block 2: Packaging

UNIT-I: Importance of packaging of fresh and processed horticultural produce, present status and future scope. Gaps in packaging concepts. Packaging requirements of fresh horticultural produce. Packaging patterns and methods. Food packaging systems: Different forms of packaging such as rigid, semi-rigid, flexible forms. Traditional, improved and specialized packages. Paper based packages: corrugated fibre board boxes - raw material and types of boxes. Flexible packaging materials - types and their properties. Consumer and intermediate flexible bulk containers. Testing of flexible packaging material. Barrier properties of packaging materials.

UNIT-II: New technology in packaging - stretch wrapping system, vacuum packaging, gas packaging,

controlled atmosphere (active and intelligent) packaging, vibra packaging, skin packaging, shrink packaging, form-fill-seal packaging, Packaging machines. Quality control and safety aspects of packaging materials.

PRACTICALS:

1. Study of special storage structures for bulk storage of onion/potato, *etc.*
2. Study of storage behavior of different fruits and vegetables in zero energy cool chamber.
3. Determination of refrigeration requirements (capacity) for given quantity of fruits and vegetables.
4. Study of storage behaviour of different fruits and vegetables in cold room.
5. Study of chilling injury and storage disorders.
6. Study of shelf-life of fruits and vegetables in modified atmosphere packaging. Visit to special storage structures, cold storage units. Study of types of packaging materials, types of plastic films and their properties.
7. Determination of water vapour transmission rate (WVTR) and gas transmission rate (GTR) of packaging material.
8. Applications of packaging material for fresh fruits and vegetables, beverages, spice products.
9. Determination of shelf-life of fresh products in different types of packages.
10. Study of packaging machines - vacuum packaging machine, shrink wrapping machine, double seamer, *etc.* Visit to packaging unit.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentations
- Group Work /seminars

RESOURCES:

Thompson A. K. (2010) Controlled atmosphere storage of fruits and vegetables (2nd Edition), CABI International, ISBN 9781845936464.

Burg S. P (Ed.) (2004) Postharvest physiology and hypobaric storage of fresh produce, CABI Publishing, ISBN 0851998011.

Coles R., McDowell D. and Kirwan M. J. (Eds.) (2003) Food Packaging Technology, Blackwell Publishing, ISBN 1841272213.

Ahvenainen R. (2003) Novel Food Packaging Techniques, CRC Press, ISBN 0849317894.

Robertson G. L. (Ed.) (2010) Food packaging and shelf life: a practical guide CRC Press, ISBN 9781420078442.

Wilson C.L. (Ed.) (2007) Intelligent and active packaging for fruits and vegetables, CRC Press, ISBN 9780849391668.

Ahvenainen R. (2001) Novel Food Packaging Techniques. CRC. A.K.

Thompson 2010, Controlled Atmosphere Storage of Fruits and Vegetables, CABI Publishing; 2nd revised edition.

Chattopadhyaya S. K. (2007) Handling, transportation and storage of fruits and vegetables. Gene-Tech books, New Delhi.

Chandra Gopala Rao (2015) Engineering for Storage of Fruits and Vegetables; Academic Press, 1st Edition.

Mahadevaiah M and Gowramma RV. (1996) Food packaging materials. Tata McGraw Hill.

Painy F.A. (1992) A handbook of food packaging. Blackie Academic.

Pantastico B. (1975) Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables. AVI Publ.

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

PHM 504: PACKAGING OF PROCESSED HORTICULTURAL PRODUCE (1+1)

WHY THIS COURSE?

Horticulture industry is dominated by market interaction in terms processing and their packaging. Much of the total cost of produce is determined by nature of packaging and packaging material used. Packaging cost sometimes exceed the raw material cost, depending on the nature of the produce, time and period. This course helps in understanding the packaging interaction with produce, environment and time. And it also helps to take informed decision on package requirement for horticulture produce.

AIM OF THIS COURSE

To acquaint with the different and packaging systems for processed horticultural produce. The course is organized as follows:

S.No	Blocks	Units
1	Packaging principles & functions	Functions of packaging
		Basic principles of packaging materials
		Manufacture of packaging materials
		Types of packaging materials
		Testing of packaging

LEARNING OUTCOMES

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

- Importance of packaging for processed horticultural produce
- Different methods of packaging, methods and their applications in food industry.

THEORY:

Block 1: Packaging principles & functions

UNIT-I: Functions of packaging; Type of packaging materials; Selection of packaging material for different foods; Selective properties of packaging film; Methods of packaging and packaging equipment.

UNIT –II: Mechanical strength of different packaging materials; Printing of packages; Barcodes & other marking; Interactions between packaging material and foods; Environmental and cost consideration in selecting packaging materials.

UNIT-III: Manufacture of packaging materials; Potential of biocomposite materials for food packaging; Packaging regulations; Packaging and food preservation; Disposal of packaging materials.

UNIT-IV: Metal cans: types, fabrication, lacquering and tin quality. Double seaming technology - defects and causes. Glass containers – types; testing quality - thermal shock resistance, thermal shock breakage, impact breakage

UNIT-V: Testing of packaging; Rigid and semi rigid containers; Flexible containers; Sealing Equipment. Labeling; Aseptic and shrink packaging; Secondary and transport packaging. Different packaging systems for dehydrated foods, frozen foods, dairy foods, fresh fruits and vegetables,

PRACTICALS:

1. Testing of packaging material: compression strength/drop test/thermal shock test/seam evaluation/seam defects.
2. Determination of shelf-life of processed products in different types of packages.
3. Study of packaging machines - vacuum packaging machine, shrink wrapping machine, double seamer, etc.
4. Visit to packaging units.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentations
- Group Discussions

RESOURCES:

Ahvenainen R. (2001) Novel Food Packaging Techniques. CRC.

A.K. Thompson 2010, Controlled Atmosphere Storage of Fruits and Vegetables, CABI Publishing; 2nd revised edition.

Ahvenainen R. (2003) Novel Food Packaging Techniques, CRC Press, ISBN 0849317894.

Coles R., McDowell D. and Kirwan M. J. (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 F.A. (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.

Wilson C.L. (Ed.) (2007) Intelligent and active packaging for fruits and vegetables, CRC Press, ISBN 9780849391668.

PHM 505: PRINCIPLES AND METHODS OF FRUIT AND VEGETABLE PRESERVATION (2+1)

WHY THIS COURSE?

The fruits and vegetables are comparative higher value than cereals and more perishables. Losses in the fruits and vegetables are high and chances to reduce the waste and enhancing the employability through post-harvest processing are more. The processing includes pre-processing of fruits and vegetables before these are fit to final conversation into processed foods. The food preservation and processing industry has now become of a necessity than being a luxury. It has an important role in conservation and better utilization of fruits and vegetables. In order to avoid the glut and utilize the surplus during the season, it is necessary to employ modern methods to extend storage life for better distribution and also processing techniques to preserve them for utilization in the off season on both large scale and small scale. Hence this customized course.

AIM OF THIS COURSE:

Understanding spoilage, underlying principles and methods of processing of fruits and vegetables.

This course is organized as follows:

S.No	Blocks	Units
1	Principles and Methods	1. Importance of fruit and vegetable processing
		2. Food spoilage and control
		3. Principles and methods of preservation
		4. Advanced preservation methods
		5. Quality management

LEARNING OUTCOMES

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

THEORY:

Block 1: Principles and Methods of Fruit and Vegetable Processing

UNIT-I: Introduction, Historical development in food processing, type of food and causes for food spoilage. Basic principles of fruits and vegetables processing;

UNIT-II: Thermal processing, pH classification of foods, heat resistance of microorganism; Heat resistance of enzymes in foods, Spoilage of thermal processed food; Containers - canning, rigid tin plates and cans, aluminium cans, glass containers – types; flexible packaging materials, Composite can, specification, corrosion of cans, heat penetration into containers and methods for determination of process time.

UNIT-III: Effects of low temperature on fresh commodities and prepared product. Freezing preservation, freezing points of foods, slow and quick freezing, Cryogenic freezing and frozen food storage. Drying and dehydration, sun drying solar dehydration, mechanical drying types of driers, osmotic dehydration.

UNIT-IV: Food fermentation – alcoholic, acetic and lactic fermentation. Pickling and curing; Effect of salt on food preservation, types of salt cured products. Traditional and new products; chemical preservation, SO₂, benzoic acid, sorbic acid, antioxidants and antibiotics, newer preservatives. Preservation by controlling water activity – high sugar products, intermediate moisture food, food concentration.

Unit-V: Food irradiation, principles, types and sources of radiation, mode of action of ionizing radiation; radiation effect on food constituents and regulation

PRACTICALS:

1. List and cost of equipment, utensils, and additives required for small scale processing industry.
2. Chemical analysis for nutritive value of fresh and processed fruits and vegetables.
3. Preparation and preservation of fruit based beverages and blended products from fruits and vegetables.
4. Evaluation of pectin grade; preparation and quality evaluation of fruit jam.
5. Preparation of papain.
6. Blanching and its effects on enzyme.
7. Preparation of dehydrated vegetables.
8. Study of different types of spoilages in fresh as well as processed horticultural produce.
9. Study of biochemical changes and enzymes associated with spoilage.
10. Sensory evaluation of fresh and processed fruits and vegetables.
11. Visit to processing units.

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Exposure visits
- Student presentation
- Group Work

RECOURCES:

Srivastava, R. P. and Kumar, S. (2014) Fruit and Vegetable Preservation: Principles and Practices (3rd Edition), CBS Publishing, ISBN 9788123924373.

Fellows, P. J. (2009) Food Processing Technology: Principles and Practice (3rd Edition), Woodhead Publishing, ISBN 9781845692162.

Barret D. M., Somogyi L. P. and Ramaswamy H. (Eds.) (2005) Processing Fruits: Science and Technology (2nd Edition), CRC Press, ISBN 9780849314780.

FAO. (2007) Handling and Preservation of Fruits and Vegetables by Combined Methods for Rural Areas- Technical Manual. FAO Agricultural Services Bulletin 149.

Lal G., Siddappa G. S. and Tandon G. L. (1998) Preservation of Fruits and Vegetables. ICAR, ISBN 9788171640904.

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.

Ramaswamy H and Marcotte M. (2006) Food Processing: Principles and Applications. Taylor & Francis.

Salunkhe D. K & Kadam S. S. (1995) Handbook of Fruit Science & Technology: Production, Composition and Processing. Marcel Dekker.

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>

PHM 506: LABORATORY TECHNIQUES IN POSTHARVEST HORTICULTURE (1+2)

WHY THIS COURSE?

To familiarize with the conventional analysis of raw and processed food products of all commodity technologies used for routine quality control in food industry, and their role on nutritional labeling. To develop an understanding and methodologies of instrumental techniques in food analysis used for objective methods of food quality parameters.

AIM OF THIS COURSE?

To familiarise with advances in instrumentation and Postharvest management

LEARNING OUTCOMES

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

- Techniques and instrumentation used in food industry
- Analysis of pesticide residues
- Quality analysis of processed fruits and vegetables
- Principles of chromatography and Spectrophotometry
- Non-destructive quality evaluation

THEORY:

Block 1: Laboratory Techniques in Postharvest Management

UNIT-I: Rheological techniques and instrumentation used in food industry. Analysis of food additives like food colour, antioxidants, emulsifier, etc.

UNIT-II: Analysis of pesticide residues, metallic contaminants, aflatoxin. Analysis of food flavours.

UNIT-III: Quality analysis of processed fruits and vegetables, coffee, tea and spices. Identification and enumeration of microbial contaminants.

UNIT-IV: Principles of chromatography (GC, GCMS, HPLC, LCMS), spectrophotometry (Atomic absorption spectrophotometer, ICAP spectrophotometer), ICP-MS, ICPOES, NMR, ESR, amino acid analyser, flame photometry, electrophoresis,

UNIT-V: Colour measurement in foods, IRGA, Radio-isotopic techniques. Non destructive quality evaluation (NDQE)- E-nose, E-tongue, machine vision. electrophoresis.

PRACTICAL:

1. Sample preparation for quality analysis. Energy calculation, sample calculations.
2. Texture analysis, Rheology of different foods.
3. Instrumental colour analysis.
4. Sensory evaluation and microbiological examinations of fresh and processed products.
5. Estimation of tannin/phytic acid by spectrometric method;
6. Moisture and fat analysis by NIR spectroscopy
7. Separation and identification of sugars in fruit juices
8. Separation and identification of carotenoids by column chromatography
9. Estimation of respiration in fruits and vegetables
10. Flavour profile in essential oils using GC
11. Identification and determination of organic acids by HPLC
12. Capsaicin content and Scoville Heat Units in chillies
13. Heavy metal analysis using atomic absorption spectrometry
14. Residue analysis.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentations

RECOURCES:

Ranganna S. (2001) Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Tata McGraw-Hill ISBN 9780074518519.

Nielsen, S. Suzanne (2010) Introduction to Food Analysis, ISBN 978-1-4419-1478-1, Springer.

Semih Otles (Editor) (2016) Methods of Analysis of Food Components and Additives (Chemical & Functional Properties of Food Components) CRC Press, ISBN-13: 978- 1138199149,

Mark F. Vitha (2016) Chromatography: Principles and Instrumentationm John Wiley & Sons, ISBN 9781119270881

Lundanes E., Reubsaet L. and Greibrokk T. (2013) Chromatography: Basic Principles, Sample Preparations and Related Methods, ISBN-13: 978-3527336203, Wiley VCH

PHM 507: PROCESSING OF HORTICULTURAL PRODUCE (2+2)

WHY THIS COURSE?

Postharvest system deals with ensuring the delivery of a crop from the time and place of harvest to the time and place of consumption, with minimum loss, maximum efficiency and returns to all concerned including grower, processors and consumer. The term 'system' represents a dynamic, complex aggregate of locally interconnected functions or operations within a particular sphere of activity. While, the term pipeline of operations refers to the functional succession of various operations but tends to ignore their complex interactions. Primary processing operations include washing/cleaning, sorting, grading, dehulling, pounding, grinding, packaging, soaking, winnowing, drying, sieving, whitening and milling and secondary operations include mixing, cooking, drying, frying, moulding, cutting, extrusion product preparation.

AIM OF THIS COURSE:

This course gives an overview of status of fruit and vegetable processing in the country, objectives and importance of preservation, important constraints and different unit operations processing industry which helps in expansion of industry and scope for further growth in this sector.

This course is organized as follows:

S.No	Blocks	Units
1	Important and Thermal process	1.Scope and Importance
		2. Thermal processes
		3. Evaporation
2.	Processing equipment and enzyme kinetics	1. Processing equipment and facilities
		2. Enzyme kinetics

LEARNING OUTCOMES

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

- Unit operations of processing
- Planning for domestic as well as commercial storage and processing facilities
- Kinetics of growth and enzyme reaction

THEORY:

Block 1: Importance and Thermal processes

UNIT I: Processing unit- layout and establishment, processing tools. Quality requirements of raw materials for processing, preparation of raw material, primary processing: grading, sorting, cleaning, washing, peeling, slicing and blanching; minimal processing.

UNIT II: Preparation of various processed products from fruits and vegetables, flowers; role of sugar and pectin in processed products. Freezing of fruits and vegetables. Containers, equipment and technologies in canning.

UNIT III: Juice extractions, clarification and preservation, recent advances in juice processing technology, application of membrane technology in processing of juices, preparation of fruit beverages and juice concentrate. Sensory evaluation.

Block 2: Processing equipment and enzyme kinetics

UNIT I: Dehydration of fruits and vegetables using various drying technologies and equipment, solar drying and dehydration, packaging technique for processed products.

UNIT II: Quality assurance and storage system for processed products. Nutritive value of raw and processed products, plant sanitation and waste disposal. Types of horticultural and vegetables wastes and their uses, utilization of by- products from fruits and vegetables processing industries.

PRACTICALS:

1. Handling of harvesting equipments
2. Determination of physical and thermal properties of horticultural commodities
3. Thermal process calculations
4. Particle size analysis, Storage structure design
5. Numerical problems in freezing, drying, conveying and calculations pertaining to texture and Rheology
6. Handling of heating equipment, pulper, juice extractor, deaerator, juice filters
7. Processing industries waste treatment
8. Working of a canning unit;
9. Visit to commercial processing units and storage units.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentations

RESOURCES

Cristina Ratti (2008) Advances in Food Dehydration, CRC Press, ISBN 9781420052527.

Karel M. and Lund D.B. (2003) Physical Principles of Food Preservation (2nd Edition), CRC Press, ISBN 9780824740634.

Toledo R. T. (2007) Fundamentals of Food Process Engineering (3rd Edition), Springer, ISBN 9780387290195.

Rao D.G. (2010) Fundamentals of Food Engineering, PHI Learning Pvt. Ltd., ISBN9788120338715.

Paul Singh R. and Heldman D. R. (2009) Introduction to Food Engineering (4th Edition), Academic Press, ISBN 9780123709004.

Smith P. G. (2011) Introduction to Food Process Engineering, Springer, ISBN 9781441976611.

PHM 508: QUALITY ASSURANCE, SAFETY AND SENSORY EVALUATION OF FRESH AND PROCESSED HORTICULTURAL PRODUCE (2+1)

WHY THIS COURSE?

The quality of fresh horticultural commodities is a combination of characteristics, attributes, and properties that give the commodity value for food (fruits and vegetables) and enjoyment (ornamentals). Producers are concerned that their commodities have good appearance and few visual defects, but for them a useful cultivar must score high on yield, disease resistance, ease of harvest, and shipping quality. To receivers and market distributors, appearance quality is most important; they are also keenly interested in firmness and long storage life. Although consumers buy on the basis of appearance and feel, their satisfaction and repeat purchases are dependent upon good edible quality. Assurance of safety of the products sold is extremely important to the consumers. Hence this customized course.

AIM OF THIS COURSE?

To understand the quality and safety management system and the process of sensory analysis for horticultural products

This course is organized as follows:

S.No	Blocks	Units
1	Quality Assurance	1. Concept of quality
		2. Food laws and regulations
2	Safety	1. Food safety
		2. Quality management
3.	Sensory Evaluation	1. Introduction to sensory Evaluation
		2. Methods of sensory evaluation

LEARNING OUTCOMES

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

THEORY:

Block 1: Quality Assurance

UNIT-I: Concept of quality: Quality attributes- physical, chemical, nutritional, microbial, and sensory; their measurement and evaluation. Concepts of quality management: Objectives, importance and functions of quality control; Quality management systems in India; Sampling procedures and plans.

UNIT-II: Food laws and regulations in India, Quality management standards, ISO, BIS, PFA, AGMARK and QMS standards, quality system components and their requirements.

Block 2: Safety

UNIT I: Food safety and standards act (FSSA, 2006) ; Strategies for compliance with international agri-food standards; Export specification and guidelines by APEDA. Hazard analysis and critical control points (HACCP), design and implementation of an HACCP system, steps in the risk management process. Traceability in food supply chains

UNIT-II: Organic Certification, GAP, GMP, TQM. Indian and International quality systems and standard like, Codex Alimentarius, ISO, etc. Consumer perception of safety; Ethics in food safety.

Block 3: Sensory Evaluation

UNIT-I: Introduction to sensory analysis; general testing conditions, Requirements of sensory laboratory; organizing sensory evaluation programme. Selection of sensory panellists; Factors influencing sensory measurements; Sensory quality parameters -Size and shape, texture, aroma, taste, colour and gloss; Detection, threshold and dilution tests. Different tests for sensory evaluation– discrimination, descriptive, affective; Flavour profile and tests; Ranking tests;

UNIT-II: Methods of sensory evaluation of different food products. Designing of experiments. Handling and interpretation of Data. Role of sensory evaluation in product optimization. Relationship between objective and subjective methods. Sensory analysis for consumer evaluation. Computer-aided sensory evaluation of food and beverage

PRACTICALS:

1. Analysis for TSS, pH, acidity, sugars, pectic substances, minerals, vitamin C, carotene, alcohol, benzoic acid and SO₂ contents, yeast and microbial examination in processed products.
2. Demonstration of measurement of vacuum/pressure, head space, filled weight, drained weight, cut-out analysis and chemical additives.
3. Moisture content, rehydration ratio and enzymatic/non-enzymatic browning in dehydrated products.
4. Analysis of spices for quality parameters. Evaluation of processed products according to FSSAI specification.
5. Selection and training of sensory panel.
6. Identification of basic taste, odour, texture and colour.
7. Detection and threshold tests; Ranking tests for taste, aroma, colour and texture; Sensory evaluation of various horticultural processed products using different scales, score cards and tests, Hedonic testing.
8. Estimation of color and texture; optimising a product by sensory analysis.
9. Studying relationship between objective and subjective methods

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)
- Exposure visits
- Student presentation

RESOURCES

Ranganna S. (2001) Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Tata McGraw-Hill ISBN 9780074518519.

Sarah E. Kemp, Tracey Hollowood, Joanne Hort (2009) Sensory Evaluation: A Practical Hand book, Wiley- Blackwell Publisher, ISBN 9781405162104.

Lawless, Harry T., Heymann, Hildegard (2010) Sensory Evaluation of Food: Principles and Practices, Springer, ISBN 9781441964885.

DGHS Manual 8: Manual of Methods of Analysis of Foods-Food Additives.

Patricia A. Curtis (2005) Guide to Food Laws and Regulations, Wiley-Blackwell, ISBN9780813819464.

Early R. (1995) Guide to Quality Management Systems for the Food Industry, Springer, ISBN 9781461358879.

Ranganna S. (2001) Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Tata McGraw-Hill ISBN 9780074518519.

Patricia A. Curtis (2005) Guide to Food Laws and Regulations, Wiley-Blackwell, ISBN9780813819464.

The Food Safety and Standards act, 2006 along with Rules & Regulations 2011, Commercial Law Publishers (India) Pvt. Ltd.

Amerine M. A., Pangborn R. M. & Rosslos E. B. (1965) Principles of Sensory Evaluation of Food. Academic Press.

Krammer A and Twigg B. A. (1973) Quality Control in Food Industry. Vol. I, II. AVI Publ.

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/>

PHM 509: FUNCTIONAL FOODS FROM HORTICULTURAL PRODUCE (2+0)

WHY THIS COURSE?

Functional foods are foods that have a potentially positive effect on health beyond basic nutrition. This course examines the rapidly growing field of functional foods in the prevention and management of chronic and infectious diseases. It attempts to provide a unified and systematic account of functional foods by illustrating the connections among the different disciplines needed to understand foods and nutrients, mainly: food science, nutrition, pharmacology, toxicology and manufacturing technology. Advances within and among all these fields are critical for the successful development and application of functional foods

AIM OF THIS COURSE:

To familiarise with functional foods from horticultural produce This course is organized as follows:

S.No	Blocks	Units
1	Functional food and importance	1. Introduction, Sources and classification
		2. Functional Ingredients
2.	Bioactive Compounds	1. Introduction and classes of bioactive compounds
		2. Mechanism of Neuroprotection
3.	Nutraceuticals	1. Introduction, classification, role and health benefits

LEARNING OUTCOMES

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

- Importance of functional foods
- Functional ingredients and their properties
- Classes of bioactive compounds present in fruits and vegetables
- Mechanism of neuroprotection by bioactive compounds
- Importance of Nutraceuticals

THEORY:

Block 1: Functional food and importance

UNIT-I: Functional foods- Introduction, definition, history; Importance, relevance and need of functional foods. Sources and classification of functional foods. Importance of horticultural produce as functional foods. Functional foods derived from fruits, vegetables, medicinal and aromatics.

UNIT-II: Functional ingredients and their properties. Therapeutic potential and effects of horticultural produce; Herbs, herbal teas, oils, etc. in the prevention and treatment of various diseases. Effect of preservation and processing on functional properties of horticulture produce.

Block 2: Bioactive Compounds

UNIT-I: Introduction, Classes of bioactive compounds present in fruits and vegetables. Polyphenols: Phenolic acid, Stilbenes, Flavonoids, Lignin, Coumarin, Tannin etc. –their chemistry, source, bioavailability, interaction in food systems; changes during storage and processing. Alkaloids; Nitrogen Containing Compounds; Sulphur compounds; phytosterols; carotenoids; dietary fibres etc.–their chemistry, source, bioavailability, interaction in food systems; changes during storage and processing.

UNIT-II: Mechanism of neuroprotection by bioactive compounds. Techniques of Extraction, purification and concentration of bioactive compounds from fruits and vegetables. Bioactive compound and health benefits. Incorporation of bioactive compounds in foods.

Block-3: Nutraceuticals

UNIT-I:Nutraceuticals- Introduction, classification of nutraceuticals, dietary supplements, fortified foods, functional foods and phytonutraceuticals. Role of medicinal and aromatic plants in nutraceutical industry. Health benefits of phytoneutraceuticals.

TEACHING METHODS / ACTIVITIES

- 1) Lectures
- 2) Assignment (Reading/Writing)
- 3) Exposure visits
- 4) Student presentation

RESOURCES:

Vattem, D. A (2016) Functional Foods, Nutraceuticals and Natural Products Concepts And Applications. DEStech Publications, Inc ISBN No. 978-1-60595-101-0

Interventions in the Processing of Fruits and Vegetables, Apple Academic Press, ISBN 9781771885867.

Rosa L. A., Alvarez-Parrilla E. and Gonzalez-Aguilar G. A. (2009) Fruit and Vegetable Phytochemicals: Chemistry, Nutritional Value and Stability, Wiley-Blackwell, ISBN 9780813803203.

Watson R. R. and Preedy V. (2009) Bioactive Foods in Promoting Health: Fruits and Vegetables (1st Edition), Academic Press, ISBN 9780123746283

PHM 510: MARKETING AND ENTREPRENEURSHIP IN POST HARVEST HORTICULTURE (1+1)

WHY THIS COURSE?

To develop marketing strategies and equip individuals to start their own food service. To develop Techniques for the development of entrepreneurial skills, positive self image and locus of control

AIM OF THIS COURSE:

To understand the market channel and appraise entrepreneurship opportunity in postharvest operations. This course is organized as follows:

S.No	Blocks	Units
1	Marketing and entrepreneurship in processing industry	1. Entrepreneurship
		2. Business Plan
		3. MSME Enterprise
		4. Marketing
		5. Institutional supports

LEARNING OUTCOMES

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

- Concept of entrepreneurship
- Writing Business Plan
- Steps in establishment of MSME Enterprise
- Marketing management
- Institutional support to Entrepreneurship

THEORY:

UNIT-I: Entrepreneurship – Concept, need for entrepreneurship - Types of entrepreneurs - entrepreneurial opportunities in horticultural processing sector-Government schemes and incentives for promotion of entrepreneurship in processing sector

UNIT-II: Writing Business Plan- Business Plan Format for Small and micro Enterprises- Generation, incubation and commercialization of business ideas - Environment scanning and opportunity identification

UNIT-III: Steps in establishment of MSME Enterprise - Planning of an enterprise - Formulation and project report-Meaning - Importance Components and preparation.- Government Formalities and Procedures-

UNIT-IV: Marketing potential of processed products at domestic and international level- Marketing management-Marketing functions, market information and market research- Problems in marketing of processed products-Demand and supply analysis of important processed products- Marketing channels - Marketing strategy (product strategy and pricing strategy)- Supply chain management - Meaning, importance, advantages, supply chain management of important processed products

UNIT-V: Institutional support to Entrepreneurship Role of Directorate of Industries, District Industries, Centres (DICs), Industrial Development Corporation (IDC), State Financial corporation (SFCs), Commercial banks Small Scale Industries Development Corporations (SSIDCs), Khadi and village Industries Commission (KVIC), National Small Industries Corporation (NSIC), Small Industries Development Bank of India (SIDBI)

PRACTICALS:

1. Consumer Behaviour towards Processed Foods
2. An Empirical Test-Carrying out the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of successful Enterprises-
3. Constraints in setting up of horti based industries

4. Field visits to study any one of the Local Financial Institutions to study the MSME Policies
5. Preparation of business plan and proposal writing-Project evaluation techniques- Discounted and undiscounted techniques
6. Case studies of successful entrepreneurs

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Exposure visits
- Student presentation

RESOURCES:

Adhikary, Manas Mohan. (2014) Enterprise and Entrepreneurship for Agri-Business Management and Planning. Daya Publishing House. New Delhi

Bhaskaran, S. (2014) Entrepreneurship Development & Management. Aman Publishing House, Meerut

Choudhury, Monalisa and Nayan Barua. (2014) Marketing of Processed Fruit and Vegetable. Daya Publishing House. New Delhi

Gaur, S C. 2012. Handbook of Agro Food Processing and Marketing. Agrobios. Jodhpur

Kadam and Bishe. (2018) Textbook on Agricultural Entrepreneurship. Narendra publishing house. New Delhi

Sudheer K P and Indira, V. (2018) Entrepreneurship and Skill Development in Horticultural Processing. New India Publishing Agency. New Delhi

Sudheer, K P and Indira, V. (2018) Entrepreneurship Development in Food Processing. New India Publishing Agency. New Delhi

Ph. D. Syllabus

PHM 601: RIPENING AND SENESCENCE OF FRUITS AND VEGETABLES (1+1)

WHY THIS COURSE?

Fleshy fruit experiences profound physiological, biochemical, and structural modifications during ripening to facilitate seed dispersal and to become attractive and nutritious for human consumption. The metabolic networks regulating fruit ripening are very complex, and ethylene appears to be a key factor acting in concert with other environmental signals and endogenous factors. The classical distinction between climacteric and nonclimacteric ripening is now questionable, as different patterns of synthesis and sensitivity to ethylene may operate in the ripening of different fruits. In recent years, much progress has been done in the characterization of the main biochemical pathways implicated in the different ripening-associated processes and in the identification of key genes controlling these events. This course highlights current understanding and advances in the regulation of fruit ripening and key metabolic pathways associated with the different ripening-related processes, with emphasis on their impact on fruit quality.

AIM OF THE COURSE: To impart knowledge about physiological and molecular changes during senescence and ripening.

LEARNING OUTCOMES

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

- Physiological, biochemical and structural changes during senescence and ripening.

THEORY:

Block 1:

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, biotechnological approaches to manipulate ethylene biosynthesis and action.

UNIT V: Alternate post harvest methodology and quality attributes. Scope for genetic modification of post harvest life on flowers and fruits. Uses of GM crops and ecological risk assessment.

PRACTICALS

1. Physiological and biochemical changes during senescence and ripening,
2. Estimation of ethylene during senescence and ripening,
3. Determination of Reactive Oxygen Species and scavenging enzymes,
4. Measurement of dark and alternate respiration rates during senescence and ripening.
5. Estimation of ripening related enzyme activity, cellulases, pectin methyl esterases, polygalacturonase, etc.

RESOURCES:

Knee, M. 2002. Fruit Quality and its Biological Basis. Sheffield Academic Press, CRC Press.

Khan, N.A. 2006. Ethylene action in plants. Springer Verlag.

Davis, P.J. 2004. Plant Hormone: Biosynthesis, Signal transduction and action. Kluwer Academic Publishers.

Bartz, J.A. and Brecht, J.K. 2003. Post harvest physiology and pathology of vegetables. Marcel Dekker Inc.

Seymour, G., Taylor, J. and Tucker, G. 1993. Biochemistry of fruit ripening. Edited Chapman and Hall, London.

Valpuesta, V. 2002. Fruit and vegetable biotechnology. Woodhead Publishing Limited, Cambridge, England.

Dris, R. and Jain, S.M. 2004. Production practices and quality assessment of food crops, Vol. 4: Post harvest treatment and Technology. Kluwer Academic Publisher.

Paliyath, G. Murr, D.P., Handa, A.K. and Lurie, S. 2008. Post harvest biology and technology of fruits, Vegetables and Flowers. Blackwell Publishing, Iowa, USA.

Nooden, L.D. 2004. Plant Cell Death Processes. Elsevier Science, USA.

PHM-602: RECENT TRENDS IN FOOD PRESERVATION (1+1)

WHY THIS COURSE?

Commendable production with short storage life and strategic selling limits the produce to huge loss after harvest. To prevent the postharvest loss preservation of produce with appropriate technique enhances the finished product shelf life nearly 10 to 30 times. Food processing combines raw food ingredients to produce marketable food products that can be easily prepared and served by the consumer. Emerging technologies which have already found in the food industry or related sector are High pressure processing, pulsed electric fields, ultrasound, and cold plasma. The basic principles of these technologies as well as the state of the art concerning their impact on biological cells, enzymes, and food constituents.

AIM OF THIS COURSE:

The present subject imparts knowledge on recent advancement in food preservation technologies. The basic principles of preservation technologies as well as the state of the art concerning their impact on biological cells, enzymes and food constituents. Current and potential applications will be discussed, focusing on process-structure-function relationships, as well as recent advances in the food process development that make foods.

The course is organized as follows:

S.No	Blocks	Units
1	Hurdle Technology and recent advances	1. Hurdle technology
		2. Thermal and Non-thermal technology
		3. Recent food preservation techniques
2	Enzyme applications and quality parameters	1. Enzyme and their applications
		2. Quality specifications and standards

LEARNING OUTCOMES

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

- Understand the latest methods and techniques in preservation of food particularly of horticultural produce

THEORY:

Block 1: Hurdle technology and recent advances

UNIT I: Hurdle technology, Principles of Hurdle Technology, Minimally Processed foods, Intermediate moisture foods, role of water activity in food preservation, Chemicals and biochemicals used in Food Preservation- Natural food preservatives, bacteriocins.

UNIT II: Thermal and Non-thermal technology, Advanced Thermal and Nonthermal Technology- Pulsed electric field, microbial inactivation, application, present status and future scope. Fundamentals and Applications of High Pressure Processing to Foods, Advances in Use of High Pressure to Processing and Preservation of Plant Foods, Commercial High-Pressure Equipment. Food Irradiation - an Emerging Technology.

UNIT III: Recent food preservation techniques, Ultraviolet Light and Food Preservation; Microbial Inactivation by Ultrasound; Use of oscillating Magnetic Fields. Nonthermal Technologies in Combination with Other Preservation Factors. Preservation by ohmic heating-Advances in Ohmic Heating and Moderate Electric Field (MEF) Processing; Radio- Frequency Heating in Food Processing; Current State of Microwave Applications to Food Processing. Supercritical Fluid Extraction: An Alternative to Isolating bioactive compounds.

Block 2: Enzyme applications and quality parameters

UNIT I: Enzyme and their applications. Enzyme and their application in food processing, Principles of food

biotechnology, fermentation and enzyme mediated food processing, production of high value products such as Single Cell Protein, nutritional additives, pigments and flavours.

Unit II: Quality specifications and standards. Quality parameters and specifications, Food laws and standards, HACCP, FSSAI amendments, ISO, FDA.

PRACTICALS

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 in each 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 & others .

Incubation techniques of enzymes using fermenter for juice extractions

Group discussions on current market potential of hurdle technology – Pros and cons. Visit to advanced food processing unit.

Visit to SCFE unit

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignment (Reading/Writing)
- Student presentation

RESOURCES

Karel M. and Lund D.B. (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.

Barbosa C. G. V., Pothakamury U. R., Palou E. and Swanson B. G. (1998) Nonthermal Preservation of Foods, Marcel Dekker Inc., ISBN 9780824799793.

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-2017-5-6-363-371.pdf>

<https://www.omicsonline.org/conferences-list/food-processing-technologies-and-advances-in-food-preservation>

<https://www.elsevier.com/books/advances-in-cold-plasma-applications-for-food-safety-and-preservation/bermudez-aguirre/978-0-12-814921-8> <https://www.elsevier.com/books/advances-in-cold-plasma-applications-for-food-safety-and-preservation/bermudez-aguirre/978-0-12-814921-8>

PHM-603: MANAGEMENT AND UTILIZATION OF HORTICULTURAL PROCESSING WASTE (3+0)

WHY THIS COURSE?

Processing of fruit and vegetables generates varying level and kinds of wastage that can be managed differently. With the rapid progress in establishment of processing industries in our country on account of liberal government policies, the importance of waste management has become an essential and integral part of plant design as the inappropriate disposal of wastage has already caused great loss to environment and public health. Food processing is a capital intensive, high energy and water consuming, and moderate to highly polluting industry. However, one can minimize adverse effects on environment and public health and may also augment profit of processing unit by judicious disposal and utilization of waste materials. They can be used in composting, cattle feeding and biogas generation and certain types may also be utilized in production of value added products.

AIM OF THIS COURSE:

Understanding the utilization and efficient management of waste from horticultural processing industry.

The course is organized as follows:

S.No	Blocks	Units
1	Wastetreatment anddisposal methods	1. Introduction
		2. Waste treatment processes
		3. Waste disposal methods
2	Valorisation of wastes	1. Recovery of useful products
		2. Treatment of solid and liquid waste

LEARNING OUTCOMES

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

THEORY:

Block 1: Waste treatment and disposal methods

UNIT I: Introduction: Waste and its consequences in pollution and global warming. Need for waste management. Waste and its classifications and characterization-sampling methods, analysis and standards for waste 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 industry and their present disposal methods. Waste segregation, Primary secondary and tertiary waste treatment processes, Conventional and non-conventional waste treatment processes, aerobic andanaerobic waste treatment processes.

Block 2: Valorisation of wastes

UNIT I: Recovery of useful products: Valorization of wastes: Recovery of useful products and by-products from waste, viz., organic acids, bioethanol, biobutanol, colour, essence, pectin, oils, etc. animal feed and single cell protein.

UNIT II: Treatment of solid and liquid waste: Technology of treatment of solid and liquid wastes from fruit and vegetable industries.Immobilized bioreactor in waste treatment.Anaerobic bioreactor and energy production.Circular economics and waste management.

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignments (Reading/Writing)

- Student presentations

RESOURCES

Arvanitoyannis I. S. (2008) Waste Management for the Food Industries, Academic Press, ISBN 9780123736543.

Waldron K. (Ed.) (2007) Handbook of waste management and co-product recovery in food processing, CRC Press, ISBN 9780849391323.

Joshi V. K. and Sharma S. K. (2011) Food Processing Waste Management: Treatment and Utilization Technology, New India Publishing Agency, ISBN 9789380235592.

websites <https://www.cabdirect.org/cabdirect/abstract/20153005486>
<http://www.3rmanagement.in/service/horticulture-waste-management/>

PHM 604: SUPPLY CHAIN MANAGEMENT OF PERISHABLES (2+0)

WHY THIS COURSE?

Supply chain management is the management of the flow of goods and services and includes all processes that transform raw materials into final products. It involves the active streamlining of a business's supply-side activities to maximize customer value and gain a competitive advantage in the marketplace. SCM represents an effort by suppliers to develop and implement supply chains that are as efficient and economical as possible. Supply chains cover everything from production to product development to the information systems needed to direct these undertakings. Because of this, effective supply chain management also requires change management, collaboration and risk management to create alignment and communication between all the entities.

AIM OF THIS COURSE:

To understand the intricacies of perishable supply chain and its management. The course is organized as follows:

S.No	Blocks	Units
1	Supply chain management perishables	1. Introduction
		2. Intrinsic Issues
		3. Support system in supply chain- Infrastructure
		4. Support system in supply chain- Finance
		5. Support system in supply chain- Government

LEARNING OUTCOMES

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

- Can identify the problems related waste treatments and disposal methods

THEORY

Block 1: Supply chain management of perishables

UNIT-I: Introduction. Role of supply chain and logistics, Challenges faced in supply 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 Price risk. Management 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, Role and Relevance, Problems in Synchronization, Role of Technology; Credit Structure in India - Reserve Bank of India (RBI), NABARD; Commodity Markets, Corporates in Agribusiness.

UNIT-V: Support system in supply chain- Role of Government: Introduction; Agencies- As a Direct Player. Measures for improving supply chain and its effectiveness, involvement of organized retailers.

PRACTICAL:

1. Present scenario of supply chain management,
2. Case Study: Supply chain management of fruits and vegetables in Safal daily fresh/APMC/RelianceFresh/Amul/D-Mart/Spencer Retail/Vipani/Farmers Bazars/Farm Fresh/Api Mandi, etc. based on regional importance

TEACHING METHODS / ACTIVITIES

- Lectures
- Assignment (Reading/Writing)

- Student presentationz

RESOURCES

Chandrasekaran N. and Raghuram G. (2014) Agribusiness Supply Chain Management, CRC Press, 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/>

PHM 605: EXPORT ORIENTED HORTICULTURE (1+0)

WHY THIS COURSE?

This course relates the national economy which is dependent on the contribution of the export-oriented income. Export oriented policies and laws must be followed by the growersto meet the requirement of the importing countries.

AIM OF THIS COURSE

To acquaint the students with the export oriented requirements of horticultural crops. The course is organized as follows:

S.No	Blocks	Units
1	Product specifications andsanitary measures	1. Introduction
		2. Produce specifications and standards
		3. Export oriented sanitary measures
2	Export related policies	1. Export implications
		2. Treatment of solid and liquid waste

LEARNING OUTCOMES

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 concentration of buying power, buyers' access to information, switching opportunities and costs, *etc.*

THEORY

Block 1: Product specifications and sanitary measures

UNIT I: Introduction: India's position and potentiality in world trade; export promotion zones in India. Export and import policy, problem in export of fresh horticultural produce, export infrastructure (sea port, airport, bulk storage facilities, irradiation, Vapour Heat Treatment, quarantine, transportation etc.), quarantine need, major export destination and competing 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-added products, Postharvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; APEDA and its role in export, WTO and its implications, sanitary and phyto-sanitary measures. Codex norms and GAP and SOP for export of smajorhorticultural crops from India.

Block 2: Export related policies

UNIT I: Export implications: Export of seed and planting material; implications of PBR, treatments of horticultural produce, MRL for export of horticultural produce.

UNIT II: Export oriented regulatory issues: Agriculture Export Policy, Export procedure; EXIM Policy, APMC act, Auction Centres, Regulatory issues of Ministry of Commerce, GoI.

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Student presentation

RESOURCES

- Islam, C.N. (1990) Horticultural Export of Developing Countries: Past preferences, future prospects and policies. International Institute of Food Policy Research, USA.
- Bartz, J.A. and Brecht, J.K. (2002) Postharvest Physiology and Pathology of Vegetables (IIInd Edition) Marcel Dekkar, Inc, New York.
- Sheela, V.L. (2007) Flowers in Trade. New India Publ. Agency.
- Bhattacharjee, SK. 2006. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
- Bose, T. K. and Yadav, L. P. (1989) Commercial Flowers. NayaProkash, Kolkata.
- Bose, T.K, Maiti, R.G., Dhua, R.S. and Das, P. (1999) Floriculture and Landscaping. NayaProkash.
- Chadha, K.L. (1995) Advances in Horticulture. Vol. XII. Malhotra Publ. House.
- Reddy, S., Janakiram, T., Balaji, T., Kulkarni, S. and Misra, R. L. (2007) Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

PHM 606: FOOD ADDITIVES (1+1)

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 are used in today's food supply to prevent foodborne illness, enable the transportation of food to areas that otherwise wouldn't be possible, and for the efficient manufacture of products to consistently meet the established quality standards. Although there may be certain ill effects of additives and preservatives in food, they increase its shelf life and help retain the flavour, color, and texture. They also help maintain or increase the nutritive value of food. Hence this customized course.

AIM OF THIS COURSE?

To understand the chemistry of food additives and their functions in food processing This course is organized as follows:

S.No	Blocks	Units
1	Quality control of horticultural products	1. Importance of food additives
		2. Methods of preservation
		3. Different additives types
		4. Flavour technology
		5. Use of functional ingredients and safety and toxicological evaluation

LEARNING OUTCOMES

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

- Importance of food additives in processing and preservation of horticultural produce
- About Flavour technology
- Safety and toxicological evaluation of food additives

THEORY

Block 1: FOOD ADDITIVES

UNIT-I: Importance of food additives in processing and preservation of horticultural 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, sequester ants, humectants, hydrocolloids, sweeteners, acidulants, buffering salts, anticaking agents, clarifying agents etc. – uses in horticulture foods and functions in formulations.

UNIT-IV: Flavour technology: types of flavours, flavour generated during processing – reaction flavours, flavour composites, stability of flavours during food processing, flavour emulsion, essential oils and oleoresins etc.

UNIT-V: Uses of enzymes in extraction of juices. Pectic substances and their role as jellifying agents. Protein, starches and lipids as functional ingredients, functional properties and applications in horticultural food. Safety and toxicological evaluation of food additives: GRAS-tolerance levels and toxic levels in foods, LD₅₀ value.

PRACTICALS:

1. Extraction of fruit and vegetable juices using enzymes clarification.
2. Role of additives and preservatives in RTS, cordial, squash, concentrate, syrup, jam, jelly, marmalade, ketchup, sauce, preserves, chutneys, pickles, candies, crystallized products.

3. Estimation of benzoic acid, sulphur-di-oxide.
4. Estimation of pectins.

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Exposure visits
- Student presentation

RESOURCES:

Branen A. L., Davidson P. M., Salminen S. and Thorngate III J. H. (2001) Food Additives (2nd Edition), Marcel Dekker Inc., ISBN 0824793439.

Taylor A. J. and Linforth R. S. T. (2010) Food Flavour Technology (2nd Edition), Wiley-Blackwell, ISBN 9781405185431.

Ötleş S. (Ed.) (2005) Methods of Analysis of Food Components and Additives, CRC Press, ISBN 9780849316470.

Wood R., Foster L., Damant A. and Key P. (2004) Analytical methods for food additives, CRC Press, ISBN 084932534X.

DGHS Manual 8: Manual of Methods of Analysis of Foods-Food Additives.

Michael and Ash I. (2008) Handbook of Food Additives (3rd Edition), Synapse Information Resources, Inc., ISBN 9781934764008.

George A. B. (1996) Encyclopedia of Food and Color Additives. Vol. III. CRC Press.

Madhavi D. L., Deshpande S. S. and Salunkhe D. K. (1996) Food Antioxidants: Technological, Toxicological and Health Perspective. Marcel Dekker.

Nagodawithana T and Reed G. (1993) Enzymes in food processing. Academic Press.

Websites:

Additives and colors 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>

PHM 607: ADVANCES IN PROCESSING OF PLANTATION, SPICES, MEDICINAL AND AROMATIC PLANTS (3+0)

WHY THIS COURSE?

This course deals with post-harvest operations, processing and value addition details of plantation, spices, medicinal and aromatic plants. This course would be very useful for everyone who so ever is interested to know about harvesting and handling of spices, plantation, medicinal and aromatic plants.

AIM OF THIS COURSE:

To familiarize with advances in processing of plantation, spices, medicinal and aromatic plants

The course is organized as follows:

S.No	Blocks	Units
1	Handling and utilization of plantation, spice, medicinal and aromatic plants	1. Introduction
		2. By product utilization
		3. Value addition of medicinal and aromatic plants
2	Essential oil utilization and their storage	4. Recovery of useful products
		5. Treatment of solid and liquid waste

LEARNING OUTCOMES

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

THEORY

Block 1: Handling and utilization of plantation, spice, medicinal and aromatic 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, toddy tapping, Oil cake production and utilization, vermi-composting, Fuel wood 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 on aromatic oils and medicinal herbs. Principles and practices of different types of extraction - distillation, solvent extraction, enfleurage, soxhlet, supercritical fluid extraction, phytonics, counter current extraction. Commercial uses of essential oils, aroma therapy. Commercial utilization of spent material.

Block 2: Essential oil utilization and their storage

UNIT I: Quality determination of essential oils: Qualitative determination of essential oils. Quality analysis and characterization through chromatographs.

UNIT V: Storage of essential oils: Storage of essential oils. Utilization of spent material of medicinal and aromatic crops in manufacture of agarabatti, organic manures and other useful products. Detoxification of waste materials. Role of spent material in bio-control of diseases and pest in organic farming. Role of micro-organisms in conversion of waste in to useful products.

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)

➤ Student presentation

RESOURCES

- Siddiqui M. W. (2015) Postharvest Biology and Technology of Horticultural Crops: Principles and Practices for Quality Maintenance, CRC Press, ISBN 9781771880862.
- Pruthi J. S. (1993) Major Spices of India Crop Management Postharvest Technology, ICAR Publication, ISBN 1234567147556.
- Chakraverty A., Majumdar A. S., Raghavan G. S. V. and Ramaswamy H. S. (2003) Handbook of Postharvest Technology: Cereals, Fruits, Vegetables, Tea, and Spices, CRC Press, ISBN 9780824705145.
- Chi-Tang Ho, Jen-Kun Lin, Fereidoon Shahidi (2008) Tea and Tea Products: Chemistry and Health-Promoting Properties, CRC Press, ISBN 9780849380822.
- Kumar N., Khader J. B. M. M., Rangaswami P., and Irulappan I (2017) Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants (2nd Edition), Oxford & IBH Publishers, ISBN 9788120417762.
- Afoakwa E. O. (2016) Cocoa Production and Processing Technology, CRC Press, ISBN 9781138033825.

Websites <https://www.cabdirect.org/cabdirect/abstract/20006781145>:
<https://www.springerprofessional.de/en/value-addition-in-flowers/4657550>

PHM 608: VALUE ADDITION IN ORNAMENTAL CROPS (1+1)

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 demand for floricultural products in the world resulting in growing international flower trade. Value addition in floriculture increases the economic value and consumer appeal of any floral commodity. This course will be useful as a source of income generation.

AIM OF THIS COURSE

To acquaint the students about the scope and ways of value addition in ornamental crops. The course is organized as follows:

S.No	Blocks	Units
1	Value addition of flowers	1. Introduction
		2. Value addition of flower crops
		3. Neutraceuticals from petals
2	Floral arrangements and women empowerment	1. Floral arrangements
		2. Women empowerment

LEARNING OUTCOMES

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, greeting cards etc.
- Students can give training to women and create a source of employment to rural women

THEORY

Block 1: Value addition of flowers

UNIT I: Introduction: Importance, opportunities and prospects of value addition in floriculture; national and global scenario; production and exports, supply chain management. UNIT II: Value addition of flower crops: Dry flower making including pot pourries, their uses and trade; extraction technology, uses, sources and trade in essential oils; aroma therapy; pigment and natural dyes extraction technology, sources, uses and trade.

UNIT III: Neutraceuticals from petals: Pharmaceutical and neutraceutical compounds from flower crops; petal embedded hand made paper making and 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, flower arrangements, etc. tinting (artificial colouring) of flower crops;

UNIT II: Women empowerment: Women empowerment through value added product making.

PRACTICALS

1. Dry flower making including pot pourries; extraction technology, uses, sources and trade in essential oils.
2. Pigment and natural dyes extraction technology
3. Pharmaceutical and neutraceutical compounds from flower crops
4. Preparation of products like *gulkand*, rose water, *gulroghan*, *attar*, *pankhuri*:
5. Petal embedded handmade paper making
6. Floral craft including bouquets, garlands, flower arrangements etc.
7. Tinting (artificial colouring) of flower crops.

TEACHING METHODS / ACTIVITIES

- Lecture
- Assignment (Reading/Writing)
- Student presentation
- Group Work/ Seminars
- Product preparation and income generation assessment

RESOURCES

Bhattacharjee, S.K. and De, L.C. (2004) Advances in Ornamental Horticulture Vol. V, Pointer publishers, Jaipur.

Randhawa, G.S. and Amitabha Mukhopadhyay, (2000) Floriculture in India, Allied publishers, India.

Gary L. McDaniel. (1989) Floral design and arrangement. A Reston Book. Prentice hall. New Jersey.

Lesniewicz, Paul. (1994) Bonsai in your home. Sterling publishing Co, New York.

Salunkhe, K., Bhatt, N.R. and Desai, B.B. (2004) Postharvest biotechnology of flowers and ornamental plants. Naya Prokash, Kolkata.

Lauria, A. and Victor, H.R. (2001) Floriculture – Fundamentals and Practices. Agrobios.

Prasad, S. and Kumar, U. (2003) Commercial Floriculture. Agrobios.

Reddy, S., Janakiram, T., Balaji, T., Kulkarni, S. and Misra, R.L. (2007) Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

WEBSITES

http://www.vedamsbooks.com/no103218/user_forgot_pass.php

<https://www.springerprofessional.de/en/value-addition-in-flowers/4657550> www.ihc2018.org/en/S29.html

Suggested Journals on Postharvest Management of Horticultural Crops

	Name of Journal	ISSN
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

	Name of Journal	ISSN
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

COMMON COMPULSORY COURSES

Common compulsory courses*		
Course No.	Course Title	Cr. hr
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

** Ph.D. students need not register Common compulsory courses*

PGS 501 LIBRARY AND INFORMATION SERVICES (0+1)

Objective

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

Practical

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

PGS 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

Objective

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

Practical (Technical Writing)

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

RESOURCES

1. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
2. Collins' Cobuild English Dictionary. 1995.
3. Harper Collins. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed.
4. Holt, Rinehart & Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford Press.
5. James HS. 1994. Handbook for Technical Writing. NTC Business Books.
6. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
7. Mohan K. 2005. Speaking English Effectively. MacMillan India.
8. Richard WS. 1969. Technical Writing.
9. Barnes & Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
10. Abhishek. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
11. Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

PGS 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

Objective

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

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPs Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings

1. Erbis FH and Maredia K. 1998. *Intellectual Property Rights in Agricultural Biotechnology*. CABI.
 2. Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.
 3. *Intellectual Property Rights: Key to New Wealth Generation*. 2001. NRDC and Aesthetic Technologies.
 4. Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
 5. Rothschild M and Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.
 6. Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.
- The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; The Biological Diversity Act, 2002.

PGS 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

Objective

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

Practical

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

Suggested Readings

1. Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press.
2. Gabb MH and Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co.

PGS 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

Objective

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

Theory

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

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

UNIT III Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Readings

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

Minor Courses

S. No.	Course No.	Course Title	Credits
I	Minor Courses		08
A	Agronomy		
1	AGRON 502	Principles and practices of soil fertility and nutrient management	2+1
2	AGRON 503	Principles and Practices of Weed Management	2+1
3	AGRON 504	Principles and Practices of Water Management	2+1
4	AGRON 513	Principles and practices of organic farming	2+1
5	AGRON 602*	Recent trends in crop growth and productivity	2+1
6	AGRON 603*	Irrigation management	2+1
7	AGRON 604*	Recent trends in weed management	2+0
8	AGRON 607*	Stress crop production	2+1
B	Soil Science and Agricultural Chemistry		
1	SOIL 501	Soil Physics	2+1
2	SOIL 502	Soil Fertility and Fertilizer Use	2+1
3	SOIL 506	Soil Biology and Biochemistry	2+1
4	SOIL 508	Soil, Water and Air Pollution	2+1
5	SOIL 509	Remote Sensing and GIS Technique for Soil, Water and Crop Studies	2+1
6	SOIL 510	Analytical Techniques and Instrumental Methods in Soil and Plant Analysis	0+2
7	SOIL 511	Management of Problem Soils and Water	2+1
8	SOIL 514	Introduction to Nanotechnology	2+1
C	Genetics and Plant Breeding		
1	GPB 501	Principles of Genetics	2+1
2	GPB 502	Principles of Plant Breeding	2+1
3	GPB 503	Fundamentals of Quantitative Genetics	2+1
4	GPB 506	Molecular Breeding and Bioinformatics	2+1
5	GPB 507	Breeding for Quality and Special Traits	2+1
6	GBP 509	Hybrid Breeding	2+1
7	GPB 516	Breeding for Stress Resistance and Climate Change	2+1
8	GPB 601*	Advances in Plant Breeding Systems	3+0
9	GPB 602*	Advances in Biometrical Genetics	2+1
10	GPB 605*	Genomics in Plant Breeding	3+0
11	GPB 607*	Crop Evolution	3+0
D	Plant Physiology		
1	PP 501	Principles of Plant Physiology I - Plant Water Relations and Mineral Nutrition	2+1
2	PP502	Principles of Plant Physiology II - Metabolic Processes and Growth Regulation	2+1
3	PP 504	Physiological and Molecular Responses of Plants to Abiotic Stresses	2+1
4	PP 505	Hormonal Regulation of Plant Growth and Development	2+1
5	PP 509	Physiology of Horticulture Crops	2+0
6	PP 512	Crop Growth Regulation and Management	2+0

7	PP 602*	Signal Perceptions And Transduction And Regulation Of Physiological Processes	2+0
8	PP 606*	Global Climate Change and Crop Response	2+0
9	PP 607*	Physiological and Molecular Aspects of Source-sink Capacity for Enhancing Yield	3+0
E	Post Harvest Management		
1	PHM 501	Post harvest Management of Horticultural Produce	2+1
2	PHM-502	Post harvest Physiology and Biochemistry of Perishables	2+1
3	PHM 503	Packing and Storage of Fresh Horticultural Produce	1+1
4	PHM 507	Processing of Horticultural Produce	2+2
5	PHM 604	Supply Chain Management of Perishables	2+0
F	Microbiology		
1	MICRO 502	Principles of microbiology	3+1
2	MICRO 505	Soil Microbiology	2+1
3	MICRO 507	Food microbiology	2+1
4	MICRO 603*	Recent Developments In soil microbiology	2+0
5	MICRO 604*	Recent Approaches in Environmental Microbiology	2+0

**Starred courses are Ph.D. courses. M.Sc. students are not permitted to register.*

A. AGROMY

M.Sc. Courses

Agron 502 PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT(2+1)

Aim of the course

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

Theory

Unit I

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Practical

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

Teaching methods/activities

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

Learning outcome

Basic knowledge on soil fertility and management

Suggested Reading

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

Aim of the course

To familiarize the students about the weeds, herbicides and methods of weed control.

Theory**Unit-I**

Weed biology, and ecology and classification, crop-weed competition including allelopathy; principles and methods of weed control and weed management; weed indices, weed shift in different eco-systems

Unit II

Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

Unit III

Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides, rotation; weed control through use of nano-herbicides and bio-herbicides, myco-herbicides bio-agents, and allelochemicals; movement of herbicides in soil and plant, Degradation of herbicides in soil and plants; herbicide resistance, residue, persistence and management; development of herbicide resistance in weeds and crops and their management, herbicide combination and rotation.

Unit IV

Weed management in major crops and cropping systems; alien, invasive and parasitic weeds and their management; weed shifts in cropping systems; aquatic and perennial weed control; weed control in non-crop area.

Unit V

Integrated weed management; recent development in weed management- robotics, use of drones and aeroplanes, organics etc., cost: benefit analysis of weed management.

Practical

- Identification of important weeds of different crops,
- Preparation of a weed herbarium,
- Weed survey in crops and cropping systems,
- Crop-weed competition studies,
- Weed indices calculation and interpretation with data,
- Preparation of spray solutions of herbicides for high and low-volume sprayers,
- Use of various types of spray pumps and nozzles and calculation of swath width,
- Economics of weed control,
- Herbicide resistance analysis in plant and soil,
- Bioassay of herbicide resistance residues,
- Calculation of herbicide requirement

Teaching methods/activities

Classroom teaching with AV aids, group discussion, field visit to identify weeds.

Learning outcome

Basic knowledge on weed identification and control for crop production

Suggested Reading

Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. *Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry*. Springer.

Chauhan B and Mahajan G. 2014. *Recent Advances in Weed Management*. Springer.

Das TK. 2008. *Weed Science: Basics and Applications*, Jain Brothers (New Delhi).

Fennimore, Steven A and Bell, Carl. 2014. *Principles of Weed Control*, 4th Ed, California Weed Sci. Soc.

Gupta OP. 2007. *Weed Management: Principles and Practices*, 2nd Ed.

Jugulan, Mithila (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC press

Monaco TJ, Weller SC and Ashton FM. 2014. *Weed Science Principles and Practices*, Wiley

Powles SB and Shaner DL. 2001. *Herbicide Resistance and World Grains*, CRC Press.

Walia US. 2006. *Weed Management*, Kalyani Publishers.

Zimdahl RL. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture*, B. D. Sci. Pub.

Aim of the course

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

Theory**Unit I**

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

Unit II

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

Unit III

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

Unit IV

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

Unit V

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

Unit VI

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

Unit VII

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

Unit VIII

Hydroponics,

Unit IX

Water management of crops under climate change scenario.

Practical

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

- Measurement of irrigation water by measuring devices and calculation of irrigation efficiency
- Determination of infiltration rate by double ring infiltrometer

Teaching methods/activities

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

Learning outcome

Basic knowledge on water management for optimization of crop yield

Suggested Reading

Majumdar DK. 2014. *Irrigation Water Management: Principles and Practice*. PHL Learning private publishers

Mukund Joshi. 2013. *A Text Book of Irrigation and Water Management Hardcover*, Kalyani publishers

Lenka D. 1999. *Irrigation and Drainage*. Kalyani.

Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.

Paliwal KV. 1972. *Irrigation with Saline Water*. IARI Monograph, New Delhi.

Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.

Prihar SS and Sandhu BS. 1987. *Irrigation of Food Crops - Principles and Practices*. ICAR.

Reddy SR. 2000. *Principles of Crop Production*. Kalyani.

Singh Pratap and Maliwal PL. 2005. *Technologies for Food Security and Sustainable Agriculture*. Agrotech Publ.

Aim of the course

To study the principles and practices of organic farming for sustainable crop production.

Theory

Unit I

Organic farming - concept and definition, its relevance to India and global agriculture and future prospects; principles of organic agriculture; organics and farming standards; organic farming and sustainable agriculture; selection and conversion of land, soil and water management - land use, conservation tillage; shelter zones, hedges, pasture management, agro-forestry.

Unit II

Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures, bio-fertilizers and biogas technology.

Unit III

Farming systems, selection of crops and crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity.

Unit IV

Control of weeds, diseases and insect pest management, biological agents and pheromones, bio-pesticides.

Unit V

Socio-economic impacts; marketing and export potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Practical

- Method of making compost by aerobic method
- Method of making compost by anaerobic method
- Method of making vermicompost
- Identification and nursery raising of important agro-forestry trees and trees for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with *Rhizobium* cultures, use of *Azotobacter*, *Azospirillum*, and PSB cultures in field
- Visit to a biogas plant
- Visit to an organic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

Teaching methods/activities

Classroom teaching with AV aids, group discussion, assignment. exposure visit

Learning outcome

Basic knowledge on organic farming for sustainable agriculture and development of entrepreneurship on organic inputs.

Suggested Reading

Ananthakrishnan TN. (Ed.). 1992. *Emerging Trends in Biological Control of Phytophagous Insects*. Oxford & IBH.

Gaur AC. 1982. *A Manual of Rural Composting*, FAO/UNDP Regional Project Document, FAO.

Joshi M. 2016. *New Vistas of Organic Farming*. Scientific Publishers

Lampin N. 1990. *Organic Farming*. Press Books, Ipswich, UK.

Palaniappan SP and Anandurai K. 1999. *Organic Farming – Theory and Practice*. Scientific Publ.

Rao BV Venkata. 1995. *Small Farmer Focused Integrated Rural Development: Socio-economic Environment and Legal Perspective*: Publ.3, ParisaraprajnaParishtana, Bangalore.

- Reddy MV. (Ed.). 1995. *Soil Organisms and Litter Decomposition in the Tropics*. Oxford & IBH.
- Sharma A. 2002. *Hand Book of Organic Farming*. Agrobios.
- Singh SP. (Ed.). 1994. *Technology for Production of Natural Enemies*. PDBC, Bangalore.
- Subba Rao NS. 2002. *Soil Microbiology*. Oxford & IBH.
- Trivedi RN. 1993. *A Text Book of Environmental Sciences*, Anmol Publ.
- Veeresh GK, Shivashankar K and Suiglachar MA. 1997. *Organic Farming and Sustainable Agriculture*. Association for Promotion of Organic Farming, Bangalore.
- WHO. 1990. *Public Health Impact of Pesticides Used in Agriculture*. WHO.
- Woolmer PL and Swift MJ. 1994. *The Biological Management of Tropical Soil Fertility*. TSBF & Wiley.

Ph.D. courses

Agron 602 RECENT TRENDS IN CROP GROWTH AND PRODUCTIVITY (2+1)

Aim of the course

To study the physiology of vegetative and reproductive growth in relation to productivity of different crops in various environments.

Theory

Unit I

Plant density and crop productivity; plant and environmental factors, yield, plant distribution, strategies for maximizing solar energy utilization; leaf area; interception of solar radiation and crop growth; photosynthesis: the photosynthetic apparatus, factors essential for photosynthesis; difference in photosynthetic rates among and within species; physiological limitations to crop yield; solar radiation concept and agro-techniques for harvesting solar radiation.

Unit II

Growth analysis: concept, CGR, RGR, NAR, LAI, LAD, LAR; validity and Limitations in interpreting crop growth and development; growth curves: sigmoid, polynomial and asymptotic; root systems; root-shoot relationship; principles involved in inter and mixed cropping systems under rainfed and irrigated conditions; concept and differentiation of inter and mixed cropping; criteria in assessing the yield advantages.

Unit III

Competitive relationship and competition functions; biological and agronomic basis of yield advantage under intercropping; physiological principles of dry land crop production, constraints and remedial measures; heat unit concept of crop maturity: concept and types of heat units.

Unit IV

Concept of plant ideotypes: crop physiological and new ideotypes; characteristics of ideotype for wheat, rice, maize, etc.; concept and types of growth hormones; their role in field crop production; efficient use of resources.

Practical

- Field measurement of root-shoot relationship in crops at different growth stages
- Estimation of growth evaluating parameters like CGR, RGR, NAR, LAI etc., at different stages of crop growth
- Computation of harvest index of various crops
- Assessment of crop yield on the basis of yield attributing characters
- Construction of crop growth curves based on growth analysis data
- Computation of competition functions, viz. LER, IER aggressivity competition index etc in intercropping
- Senescence and abscission indices
- Analysis of productivity trend in un-irrigated areas
- Analysis of productivity trend in irrigated areas

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of crop growth for agricultural production

Suggested Reading

Chopra VL and Paroda RS. 1984. *Approaches for Incorporation of Drought and Salinity Resistance in Crop Plants*. Oxford & IBH.

Delvin RM and Vitham FH. 1986. *Plant Physiology*. CBS Publ.

Evans LT. 1975. *Crop Physiology*. Cambridge Univ. Press.

Evans LT. 1996. *Crop Evolution, Adaptation and Yield*. Cambridge Univ. Press.

Gupta US. (Ed.). 1995. *Production and Improvement of Crops for Drylands*. Oxford & IBH.

- Gupta US. 1988. *Progress in Crop Physiology*. Oxford & IBH.
- Kramer PJ and Boyer JS. 1995. *Water Relations of Plant and Soils*. Academic Press.
- Mukherjee S and Ghosh AK. 1996. *Plant Physiology*. Tata McGraw Hill.
- Narwal SS, Politycka B and Goswami CL. 2007. *Plant Physiology: Research Methods*. Scientific Pub.
- Tiaz L. and Zeiger E. 2006. *Plant Physiology*. Sinauer Associates, Inc.

Aim of the course

To teach students about optimization of irrigation in different crops under variable agro climatic conditions.

Theory**Unit I**

Global water resources; Water resources of India, irrigation projects during pre and post independence period and their significance in crop production; irrigation needs, atmospheric, soil, agronomic, plant and water factors affecting irrigation need; water deficits and crop growth.

Unit II

Movement of water in soil-water movement under saturated and unsaturated conditions, Poiseuille's and Darcy's law, general equation of saturated and unsaturated flow of water in soil.

Soil-plant-water relationships, evaporation, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, physiological processes and crop productivity.

Unit III

Water requirement, irrigation needs, factors affecting irrigation need; water use efficiency, Infiltration; water movement under saturated and unsaturated conditions; management practices for improving water use efficiency of crops.

Unit IV

Soil and plant water potential, SPAC, transpiration and evapotranspiration, significance of transpiration, energy utilization in transpiration, factors affecting ET, control of ET by mulching and use of anti-transpirents; fertilizer use in relation to irrigation.

Unit V

Crop water stress – water deficits and crop growth, adoptability to the crops. Water availability with relation to nutrient availability.

Unit VI

Application of irrigation water, conveyance and distribution system, irrigation efficiency; agronomic considerations in the design and operation of irrigation projects; characteristics of irrigation and farming systems affecting irrigation management.

Unit VII

Strategies of using limited water supply; factors affecting ET, control of ET by mulching and use of anti-transpirants; fertilizer use in relation to irrigation; optimizing the use of given irrigation supplies.

Unit VIII

Land suitability for irrigation, land irrigability classification; integrated water management in command areas, institution of water management in commands, farmer's participation in command areas; irrigation legislation.

Unit IX

Economic analysis of irrigation and crop planning for optimum use of irrigation water

Unit X

Crop water production function

Practical

- Determination of water infiltration characteristics and water holding capacity of soil profiles.
- Determination Moisture extraction pattern of crops
- Determination of water balance component of transplanted rice by drum culture technique
- Determination of consumptive use and water requirement of a given cropping pattern
- Determination of crop efficient of one important crop
- Planning, designing and installation of drip irrigation system
- Planning, designing and installation of sprinkler irrigation system
- Designing of drainage channel
- Measurement of irrigation efficiencies

- Determination of irrigation timing under different methods of irrigation
- Visit to irrigation command area

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Management of irrigation water for sustainable agriculture

Suggested Reading

MP. Singh 2017. Recent advances in Irrigation water management. Kalyani Publishers
 FAO. 1984. *Irrigation Practice and Water Management*. Oxford & IBH.
 Michael AM. 1978. *Irrigation: Theory and Practice*. Vikas Publ.
 Mishra RR and Ahmad M. 1987. *Manual on Irrigation and Agronomy*. Oxford & IBH.
 Panda SC. 2003. *Principles and Practices of Water Management*. Agrobios.
 Reddy SR. 2000. *Principles of Crop Production*. Kalyani.
 Sankara Reddy GH and Yellamananda Reddy. 1995. Efficient Use of Irrigation Water. In: Gupta US. (Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH.
 Singh SS. 2006. Principles and Practices of Agronomy. In: Gupta US.(Ed.). *Production and Improvement of Crops for Drylands*. Oxford & IBH

Aim of the course

To teach about the changing weed flora, new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Theory**Unit I**

Crop-weed competition in different cropping situations; changes in weed flora, various causes and effects; different methods of weed management. Migration, introduction, adaptation of weeds, Invasive weeds – biology and management. Different mechanisms of invasion – present status and factors influencing weed invasion.

Unit II

Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

Unit III

Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, Degradation of herbicides in soil and plants- factors affecting it, primary and secondary metabolites, residue management of herbicides, adjuvants.

Unit IV

Advances in herbicide products and application techniques and methods; herbicide resistance; antidotes and crop protection compatibility of herbicides of different groups; compatibility of herbicides with other pesticides; herbicide rotation and herbicide mixtures.

Unit V

Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

Unit VI

Relationship of herbicides with tillage, fertilizer, and irrigation, cropping system; bioherbicides, allelochemical and alleloherbicides, herbicide bioassays. Recent advances in nonchemical weed management including deleterious rhizobacteria, robotics, biodegradable film, etc.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of new herbicides, their resistance, toxicity, antidotes and residue management under different cropping systems.

Suggested Reading

Böger, Peter, Wakabayashi, Ko, Hirai, Kenji (Eds.). 2002. *Herbicide Classes in Development. Mode of Action, Targets, Genetic Engineering, Chemistry*. Springer.

Das TK. 2008. *Weed Science: Basics and Applications*, Jain Brothers (New Delhi)

Fennimore, Steven A and Bell, Carl. 2014. *Principles of Weed Control*, 4th Ed, California Weed Sci. Soc.

Gupta OP. 2007. *Weed Management: Principles and Practices*, 2nd Ed.

Jugulan M, (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC Press

Monaco TJ, Weller SC and Ashton FM. 2014. *Weed Science Principles and Practices*, Wiley

Powles SB and Shaner DL. 2001. *Herbicide Resistance and World Grains*, CRC Press.

Walia US. 2006. *Weed Management*, Kalyani publishers.

Zimdahl RL. (ed). 2018. *Integrated Weed Management for Sustainable Agriculture*, B. D. Sci. Pub

Aim of the course

To study various types of stresses in crop production and strategies to overcome them.

Theory**Unit I**

Stress and strain terminology; nature and stress injury and resistance; causes of stress.

Unit II

Low temperature stress: freezing injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature stress through, soil and crop manipulations.

Unit III

High temperature or heat stress: meaning of heat stress, heat injury and resistance in plants, practical ways to overcome the effect of heat stress through soil and crop manipulations.

Unit IV

Water deficit stress: meaning of plant water deficient stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop manipulations.

Unit V

Excess water or flooding stress: meaning of excess water stress, its kinds and effects on crop plants, excess water stress injury and resistance, practical ways to overcome excess water stress through soil and crop manipulations.

Unit VI

Salt stress: meaning of salt stress and its effect on crop growth, salt stress injury and resistance in plants, practical ways to overcome the effect of salt stress through soil and crop manipulations.

Unit VII

Mechanical impedance of soil and its impact on plant growth; Measures to overcome soil mechanical impedance.

Unit VIII

Environmental pollution: air, soil and water pollution, and their effect on crop growth and quality of produce; ways and means to prevent environmental pollution.

Practical

- Determination of electrical conductivity of plant cell sap
- Determination of osmotic potential and tissue water potential
- Measurement of transpiration rate
- Measurement of stomatal frequency
- Measurement of Relative Water Content of leaf
- Measurement of electrolytic leakage
- Growing of plants in sand culture under salt stress for biochemical and physiological studies
- Studies on effect of osmotic and ionic stress on seed germination and seedling growth
- Measurement of low temperature injury under field conditions
- Studies on plant responses to excess water.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of various types of stresses in crop production and strategies to overcome these.

Suggested Reading

Baker FWG. 1989. *Drought Resistance in Cereals*. Oxon, UK.

Gupta US. (Ed.). 1988. *Physiological Aspects of Dryland Farming*. Oxford & IBH.

Kramer PJ.1983. *Water Relations of Plants*. Academic Press.

Levitt J. 1980. *Response of Plants to Environmental Stresses*. Vols. I, II. Academic Press.

Mavi HS.1978. *Introduction to Agro-meteorology*. Oxford & IBH.

Michael AM and Ojha TP.1981. *Principles of Agricultural Engineering*. Vol II. Jain Bros.

Nilsen ET and Orcut DM. 1996. *Physiology of Plants under Stress – Abiotic Factors*. John Wiley & Sons.

Singh K. 2000. *Plant Productivity under Environmental Stress*. Agribios.

Singh KN and Singh RP. 1990. *Agronomic Research Towards Sustainable Agriculture*. Indian Society of Agronomy, New Delhi.

Somani LL and Totawat KL. 1992. *Management of Salt-affected Soils and Waters*. Agrotech Publ.

Virmani SM, Katyal JC, Eswaran H and Abrol IP. 1994. *Stressed Ecosystem and Sustainable Agriculture*. Oxford & IBH.

B. SOIL SCIENCE

M.Sc. Courses

Soil 501

SOIL PHYSICS

(2+1)

Aim of the course

To impart basic knowledge about soil physical properties and processes in relation to plant growth.

Theory

Unit I

Basic principles of physics applied to soils, soil as a three phase system.

Unit II

Soil texture, textural classes, mechanical analysis, specific surface.

Unit III

Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Alleviation of soil physical constraints for crop production. Soil erosion and edibility

Unit IV

Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

Unit V

Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

Unit VI

Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

Unit VII

Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

Unit VIII

Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

Unit IX

Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management. Soil colour - components, its determination - Munsell colour chart, importance and significance of soil colour.

Practical

- Determination of B.D, P.D and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method,
- Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement of soil-water content by Time Domain Reflectometer (TDR), Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore-size, distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil physical properties and processes in relation to plant growth.

Suggested Reading

- Baver LD, Gardner WH and Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.
- Ghildyal BP and Tripathi RP. 2001. *Soil Physics*. New Age International.
- Hanks JR and Ashcroft GL. 1980. *Applied Soil Physics*. Springer Verlag.
- Hillel D. 1972. *Optimizing the Soil Physical Environment toward Greater Crop Yields*. Academic Press.
- Hillel D. 1980. *Applications of Soil Physics*. Academic Press.
- Hillel D. 1980. *Fundamentals of Soil Physics*. Academic Press.
- Hillel D. 1998. *Environmental Soil Physics*. Academic Press.
- Hillel D. 2003. *Introduction to Environmental Soil Physics*. Academic Press.
- Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.
- Kirkham D and Powers WL. 1972. *Advanced Soil Physics*. Wiley-Interscience.
- Kohnke H. 1968. *Soil Physics*. McGraw Hill.
- Lal R and Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.
- Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

Aim of the course

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory**Unit I**

Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources – fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.

Unit II

Soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; Management of fertilizer nitrogen in Horticultural crops for high fertilizer use efficiency. Functions and deficiency symptoms of Nitrogen.

Unit III

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions. Functions and deficiency symptoms of Phosphorus.

Unit IV

Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions. Functions and deficiency symptoms of Potassium.

Unit V

Sulphur - source, forms, fertilizers and their behavior in soils; role in crops and human health; calcium and magnesium – factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers. Functions and deficiency symptoms of Sulphur.

Unit VI

Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability. Functions and deficiency symptoms of Micronutrients.

Unit VII

Common soil test methods for fertilizer recommendations; quantity–intensity relationships; soil test crop response correlations and response functions.

Unit VIII

Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; speciality fertilizers concept, need and category. Current status of speciality fertilizers use in soils and crops of India. Fertigation, nano fertilizers and their use in soils and horticultural crops.

Unit IX

Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, Determination of critical limit, DRIS.

Unit X

Definition and concepts of soil health and soil quality; Longterm effects of fertilizers and soil quality. Soil health indicators and Soil health cards and its utility.

Practical

- Soil and plant sampling and processing for chemical analysis
- Determination of soil pH, total and organic carbon in soil
- Chemical analysis of soil for total and available nutrients (major and micro)
- Analysis of plants for essential elements (major and micro)
- Total N,P and K in Fertilizers

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of soil fertility and fertilizers in relation to plant growth and development.

Suggested Reading

Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.

Kabata-Pendias A and Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.

Kannaiyan S, Kumar K and Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.

Leigh J G. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.

Mengel K and Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.

Mortvedt JJ, Shuman LM, Cox FR and Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

Pierzinsky GM, Sims TJ and Vance JF. 2002. *Soils and Environmental Quality*. 2nd Ed. CRC Press.

Stevenson FJ and Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.

Tisdale SL, Nelson SL, Beaton JD and Havlin JL. 1999. *Soil Fertility and Fertilizers*. 5th Ed. Prentice Hall of India.

Troeh FR and Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

Aim of the course

To make the student aware of the problems of soil, water and air pollution associated with use of soils for crop production.

Theory**Unit I**

Soil, water and air pollution problems associated with agriculture, nature and extent.

Unit II

Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants- their CPC standards and effect on plants, animals and human beings.

Unit III

Sewage and industrial effluents—their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal.

Unit IV

Pesticides—their classification, behaviour in soil and effect on soil microorganisms.

Unit V

Toxic elements—their sources, behaviour in soils, effect on nutrients availability, effect on plant and human health.

Unit VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of green house gases—carbon dioxide, methane and nitrous oxide. Climate change and its effect on crop production.

Unit VII

Risk assessment of polluted soil, Remediation/ amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safeguard food safety, Air sampling and determination of particulate matter and oxides of sulphur, NO₂ and O₃ conc. Visit to various industrial sites to study the impact of pollutants on soil and plants.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Management of soil and water pollution

Suggested Reading

Lal R, Kimble J, Levine E and Stewart BA. 1995. *Soil Management and Greenhouse Effect*. CRC Press.

Middlebrooks EJ. 1979. *Industrial Pollution Control*. Vol. I. *Agro-Industries*. John Wiley Interscience.

Ross SM. *Toxic Metals in Soil Plant Systems*. John Wiley & Sons.

Vesilund PA and Pierce 1983. *Environmental Pollution and Control*. Ann Arbor Science Publ.

Aim of the course

To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries, and their interpretation; application of remote sensing in general and with special reference to soil, plants and yield forecasting; to impart knowledge about geo-statistical techniques with special reference to krigging, and GIS and applications in agriculture.

Theory**Unit I**

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter, basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS)

Unit II

Sensor systems-camera, microwave radio meters and scanners; fundamentals of aerial photographs and multispectral imaging, hyperspectral imaging, thermal imaging; image processing and interpretations.

Unit III

Application of remote sensing techniques-land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, waste land identification and management.

Unit IV

Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

Unit V

Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS). Drones and their application in Horticultural crops.

Practical

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photographs and satellite data for mapping of land resources, Analysis of variability of different soil properties with classical and geostatistical techniques, Creation of datafiles in a database programme, Use of GIS for soil spatial simulation and analysis, To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students.

Learning outcome

Experience on the knowledge of remote sensing and their utility in research for solving field problem.

Suggested Reading

Brady NC and Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
Elangovan K. 2006. *GIS Fundamentals, Applications and Implementations*. New India Publ. Agency.
Lillesand TM and Kiefer RW. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.
Nielsen DR and Wendroth O. 2003. *Spatial and Temporal Statistics*. Catena Verlag GmbH.
Star J and Esles J. 1990. *Geographic Information System: An Introduction*. Prentice Hall.

e-books

The nature and properties of soil:

[https://www.researchgate.net/publication/301200878The Nature and Properties of 15th edition](https://www.researchgate.net/publication/301200878The_Nature_and_Properties_of_15th_edition).

GIS fundamentals, Applications and implementations:

<https://www.nipabooks.com/info/9788189422165/gis-fundamentals-applications-and-implementations>

Remote sensing and Image interpretation:

<https://www.wiley.com/enin/Remote+Sensing+and+Image+Interpretation,+7th+Edition-p-9781118343289>

Spatial and temporal statistics

https://books.google.com/books/about/Spatial_and_Temporal_Statistics.html?id=1BBtQgAACAAJ

Geographic Information system: <https://learnforests.org/sites/default/files/GeographicInformationSystems.pdf>

(Tutorials) <http://www.gisdevelopment.net/tutorials/tuman006.html>

<http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Tutorials> (especially for ArcGIS user)

<http://www.colorado.edu/geography/gcraft/notes/datacon/dataconf.html>

http://egsc.usgs.gov/isb/pubs/gis_poster/http://www.quantdec.com/SYSEN597/

Websites:

<http://www.isro.gov.in>

<http://www.nrsc.gov.in>

<http://www.iirs.gov.in>

<http://www.nic.in>

<http://www.constelloinc.com>

<http://www.usgs.com>

Journals:

Canadian Journal of Remote Sensing: <https://www.tandfonline.com/toc/ujrs20/current>

GIScience & Remote Sensing: <https://www.tandfonline.com/toc/tgrs20/current>

IEEE Transactions on Geoscience and Remote Sensing: <https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=36>

ISPRS Journal of Photogrammetry and Remote Sensing: <https://www.journals.elsevier.com/isprs-journal-of-photogrammetry-and-remote-sensing>

International Journal of Remote Sensing: <https://www.tandfonline.com/toc/tres20/current>

Journal of the Indian Society of Remote Sensing: <https://www.springer.com/journal/12524>

Photogrammetric Engineering and Remote Sensing: <https://www.asprs.org/asprs-publications/pers>

Remote Sensing: <https://www.mdpi.com/journal/remotesensing>

Remote Sensing Letters: <https://www.tandfonline.com/toc/trsl20/current>

Remote Sensing of Environment: <https://www.journals.elsevier.com/remote-sensing-of-environment>

Soil 510 ANALYTICAL TECHNIQUE AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS (0+2)

Aim of the course

To familiarize the students with commonly used instruments – their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Practical

Unit I

Preparation of solutions for standard curves, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

Unit II

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

Unit III

Principles of visible, ultra violet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray diffractometry; identification of minerals by X-ray by different methods, CHNS analyzer.

Unit IV

Electrochemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

Unit V

Wet digestion /fusion/ extraction of soil with aquaregia with soil for elemental analysis; triacid/di-acid digestion of plant samples; determination of available and total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in soils; determination of total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in plants.

Unit VI

Drawing normalized exchange isotherms; measurement of redox potential.

Teaching methods/activities

Classroom teaching and laboratory practicals

Learning outcome

Development of confidence for setting soil testing laboratory.

Suggested Reading

- Hesse P. 1971. *Textbook of Soil Chemical Analysis*. William Clowes & Sons.
Jackson ML. 1967. *Soil Chemical Analysis*. Prentice Hall of India.
Keith A Smith 1991. *Soil Analysis; Modern Instrumental Techniques*. Marcel Dekker.
Kenneth Helrich 1990. *Official Methods of Analysis*. Association of Official Analytical Chemists.
Page AL, Miller RH and Keeney DR. 1982. *Methods of Soil Analysis*. Part II. SSSA, Madison.
Piper CE. *Soil and Plant Analysis*. Hans Publ.
Singh D, Chhonkar PK and Pandey RN. 1999. *Soil Plant Water Analysis - A Methods Manual*. IARI, New Delhi.
Tan KH. 2003. *Soil Sampling, Preparation and Analysis*. CRC Press/Taylor & Francis.
Tandon HLS. 1993. *Methods of Analysis of Soils, Fertilizers and Waters*. FDCO, New Delhi.
Vogel AL. 1979. *A Textbook of Quantitative Inorganic Analysis*. ELBS Longman.

Why this course:

To understand the causes and effects of soil physical, chemical and biological problems assessment of irrigation water quality and management of problem soils and poor quality irrigation water

Aim of the course:

To educate students about basic concepts of problem soils and Brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.

Theory**Unit I**

Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problem soils, and factors responsible.

Unit II

Morphological features of saline, sodic and saline-sodic soils; characterization of salt affected soils – soluble salts, ESP, pH; physical, chemical and microbiological properties.

Unit III

Management of salt- affected soils; salt tolerance of crops mechanism and ratings; Salt stress meaning and its effect on crop growth, monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dryland soils.

Unit IV

Acid soils – nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management.

Unit V

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

Unit VI

Agonomic practices in relation to problem soils; cropping pattern for utilizing poor quality ground waters.

Practical

- Characterization of acid, acid sulphate, salt-affected and calcareous soils
- Determination of cations (calcium, magnesium, potassium and sodium) (Na^+ , K^+ , Ca^{++} and Mg^{++}) in groundwater and soil samples
- Determination of anions (carbonates, bicarbonates, chlorides and sulphates) (Cl^- , SO_4^{--} , CO_3^{3-} and HCO_3^-) in ground waters and soil samples
- Lime and gypsum requirements of acid and sodic soils.

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students

Learning outcome

Experience on the knowledge of chemical behaviour of soil and their utility in research for solving field problem.

Suggested Readings**Books:**

- Bear, F. E. 1964. *Chemistry of the Soil*, Oxford and IBH
- Indian Society of Soil Science. 2015. *Introduction to Soil Science*, ISSS, New Delhi.
- Jurinak, J. J. 1978. *Salt-affected Soils*, Department of Soil Science and Biometeorology. Utah State Univ.
- USDA Handbook No. 60. 1954. *Diagnosis and improvement of Saline and Alkali Soils*, Oxford & IBH.

Why this course:

To understand the basics of nano science, techniques for preparation of nano size materials for agricultural use and their use in agriculture

Aim of the course:

To impart basic knowledge about nano science, properties of Nano particles and their applications in biology

Theory**Unit I**

General introduction: Basics of quantum mechanics, Harmonic oscillator, magnetic phenomena, band structure in solids, Mössbauer effect and spectroscopy, optical phenomena, bond in solids, anisotropy

Unit II

Nano structures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nano tubes and nano wires, fullerenes (buck balls, graphene). Nano fabrication and nano patterning: Optical, X-ray, and electron beam lithography, self-assembled organic layers, Process of synthesis of nano powders, electrode position important nano materials.

Unit III

Mechanical properties, magnetic properties, electrical properties, electronic conduction with nano particles, investigating and manipulating materials in the nano scale: Electron microscopy

Unit IV

Nano-biology: Interaction between bio molecules and nano particle surface, Different types of inorganic materials used for the synthesis of hybrid nano bio assemblies, Application of nano in agriculture, current status of nano bio technology, future perspectives of nano biology, nano sensors.

Practical

- Sources of nano particles and its preparation by different approaches
- Electrospinning and its use in agriculture and allied sector
- Equipments used in Nanotechnology: its principle and uses
- Acquaintances with different equipments used in nanotechnology.
- Synthesis and characterization of Ag and ZnO nano particles.
- Mode of action of ZnO nano particles against soil borne diseases
- Study on efficacy of ZnO nano particles as seed treating agent on plant growth parameters

Teaching methods/activities

Classroom teaching with AV aids, group discussion, oral presentation by students

Learning outcome

Experience on the knowledge of nano science and their utility in research for solving field problem.

Suggested Readings**Books:**

- Balandin, A.A and Wang, K.L. 2006. *Hand Book of Semiconductor Nano Structures and Nano Devices*, Wang, California. American Scientific Publishers.
- Gregory, T. 1999. *Nano Technology*, New York. Springer Verlag.
- Kumar, C.2006. *Nano technologies for the life sciences*, Weinheim: Wiley- VCH GmbH.
- Kohler, M and Frintzsche, W. 2007. *Nano technology: Introduction to nano structuring techniques*, Wiley-VCH Verlag GmbH.
- Margaret, E. K. 2009. *Nano technology for chemical and biological defence*, Dordrecht: Springer.

Other Suggestions:

e-books:

Soil Research. CSIRO Publishing (www.publish.csiro.au/sr)
<https://www.springer.com/journal/42729>
Journal of agricultural and food Chemistry. By ACS Publications. (<https://pubs.acs.org>)
<http://www.agrilearner.com/soil-chemistry-soil-fertility-nutrient-management-pdf-book-download/>
<https://www.springer.com/journal/42729>
<https://www.frontiersin.org/journals/soil-science>

Websites:

<https://www.sciencedirect.com>
<https://www.researchgate.net>
<https://academicjournals.org>
<https://agris.fao.org>
<https://link.springer.com>
<https://www.soilmanagementindia.com>
<https://www.css.cornell.edu>

Journals:

Journal of the Indian Society of Soil Science
Soil Science Society of America Journal
Advances in Soil Science
Advances in Agronomy
Advances in Soil Science
International Journal of Soil Science
Plant and Soil
Journal of the Soil Science and Plant Nutrition
Communications in Soil and Plant Analysis
Analytical Chemistry Journal
Australian Journal of Soils Research
Geoderma
AOAC Journal
Journal of Agricultural Chemistry
Journal of Geoderma.
Journal of Geology & Geosciences
Soil Biology and Biochemistry
Biology and Fertility of soils
Atmospheric Pollution Research
Environmental Pollution
Environmental Science and Pollution Research
International Journal of Environment and Pollution
Journal of Industrial Pollution Control
Marine Pollution Bulletin
Nature Environment and Pollution Technology
Pollution Research
Water, Air and Soil Pollution

C. GENETICS AND PLANT BREEDING

M.Sc. Courses

GPB 501

PRINCIPLES OF GENETICS

(2+1)

Why this course?

Genes are the backbone of all crop improvement activities. Their chemical structure and physical inheritance are pivotal for any breeding program. Therefore, it has to be the core course for master's degree in Genetics and Plant Breeding.

Aim of the course

This course is aimed at understanding the basic concepts of inheritance of genetic traits, helping students to develop their analytical, quantitative and problem-solving skills from classical to molecular genetics.

Theory

Unit I

Beginning of genetics, early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance; Multiple alleles, Gene interactions, Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

Unit II

Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.

Unit III

Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis, Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters; Regulation of gene activity in prokaryotes and eukaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression, RNA editing.

Unit IV

Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).

Unit V

Genomics and proteomics; metagenomics; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders.

Practical

- Laboratory exercises in probability and chi-square;
- Demonstration of genetic principles using laboratory organisms;
- Chromosome mapping using three-point test cross;
- Tetrad analysis; Induction and detection of mutations through genetic tests;
- DNA extraction and PCR amplification;
- Electrophoresis: basic principles and running of amplified DNA;
- Extraction of proteins and isozymes;
- Use of *Agrobacterium* mediated method and Biolistic gun;
- Detection of transgenes in the exposed plant material;
- Visit to transgenic glasshouse and learning the practical considerations.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

After passing out this course the student will be able to know the difference between the genotype and phenotype, can carry study on inheritance and also know the role of DNA and RNA in genotypic manifestation of characters.

Suggested reading

- Daniel LH and Maryellen R. 2011. *Genetics: "Analysis of Genes and Genomes"*.
Gardner EJ and Snustad DP. 1991. *Principles of Genetics*. John Wiley and Sons. 8th ed. 2006
Klug WS and Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu. Pearson Education India; Tenth edition
Lewin B. 2008. *Genes XII*. Jones and Bartlett Publ. (International Edition) Paperback, 2018
Russell PJ. 1998. *Genetics*. The Benjamin/ Cummings Publ. Co
Singh BD. 2009. *Genetics*. Kalyani Publishers (2nd Revised Edition)
Snustad DP and Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley and Sons. 6th Edition International Student Version edition
Stansfield WD. 1991. *Genetics*. Schaum Outline Series Mc Graw Hill
Strickberger MW. 2005. *Genetics (III Ed)*. Prentice Hall, New Delhi, India; 3rd ed., 2015
Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs., McGraw Hill Education; 7 edition
Uppal S, Yadav R, Singh S and Saharan RP. 2005. *Practical Manual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

Why this course?

Development of plant variety is the ultimate aim of any plant breeding program. A post graduate in the subject of agriculture must know what are the different selection methods, techniques and related crop improvement strategies. Further, knowledge of genetic resources, evolution and their role in development of noble varieties is the need of the hour. Plant Sciences–Genetics and Plant Breeding

Aim of the course

To impart theoretical knowledge and practical skills about plant breeding objectives, genetic consequences, breeding methods for crop improvement.

Theory**Unit I**

Early Plant Breeding; Accomplishments through plant breeding; Objectives of plant breeding; Patterns of Evolution in Crop Plants: Centre of Origin, Agro-biodiversity and its significance. Pre-breeding and plant introduction and role of plant genetic resources in plant breeding.

Unit II

Genetic basis of breeding: self and cross pollinated crops including mating systems and response to selection; Nature of variability, components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding.

Unit III

Pure line theory, pure line and mass selection methods; pedigree, bulk, backcross, single seed descent and multiline breeding; Population breeding in self-pollinated crops with special reference to diallel selective mating; Transgressive breeding.

Unit IV

Breeding methods in cross pollinated crops; Population breeding: mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/ inbreds. Self-incompatibility, male sterility and apomixes in crop plants and their commercial exploitation.

Unit V

Breeding methods in asexually/ clonally propagated crops, clonal selection.

Unit VI

Special breeding techniques: Mutation breeding, Breeding for abiotic and biotic stresses; Concept of plant ideotype and its role in crop improvement, concept of MAS, concept of polyploidy and wide hybridization, doubled haploidy.

Unit VII

Cultivar development: testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical

- Floral biology in self and cross pollinated species;
- Selfing and crossing techniques;
- Selection methods in segregating populations and evaluation of breeding material;
- Analysis of variance (ANOVA);
- Estimation of heritability and genetic advance;
- Maintenance of experimental records;
- Learning techniques in hybrid seed production using male-sterility in field crops;
- Prediction of performance of double cross hybrid.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

The knowledge of this course will enable the student to know breeding methods, different hybridization techniques for genomic reshuffling. The course will also acquaint the student with importance of floral biology, mutation breeding and participatory plant breeding, etc.

Suggested Reading

- Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.
- Chahal GS and Gossal, SS. 2002. *Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches*. Narosa Publishing House.
- Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.
- George A. 2012. *Principles of Plant Genetics and Breeding*. John Wiley & Sons.
- Gupta SK. 2005. *Practical Plant Breeding*. Agribios.
- Jain HK and Kharakwal MC. 2004. *Plant Breeding and–Mendelian to Molecular Approach*, Narosa Publications, New Delhi
- Roy D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publ. House.
- Sharma JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
- Sharma JP. 2010. *Principles of Vegetable Breeding*. Kalyani Publ, New Delhi.
- Simmonds NW.1990. *Principles of Crop Improvement*. English Language Book Society.
- Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.
- Singh S and Pawar IS. 2006. *Genetic Bases and Methods of Plant Breeding*. CBS.

Why this course?

Yield and quality characters are controlled by many genes and show the quantitative inheritance. If one has to go for improvement even for the components characters the knowledge of this course is very essential.

Aim of the course

To impart theoretical knowledge and computation skills regarding components of variation and variances, scales, mating designs and gene effects.

Theory**Unit I**

Introduction and historical background of quantitative genetics, Multiple factor hypothesis, Qualitative and quantitative characters, Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic, Nature of gene action- additive, dominance and epistatic, linkage effect. Principles of analysis of variance and linear model, Expected variance components, Random and fixed effect model, Comparison of means and variances for significance.

Unit II

Designs for plant breeding experiments- principles and applications; Variability parameters, concept of selection, simultaneous selection modes and selection of parents, MANOVA.

Unit III

Association analysis- Genotypic and phenotypic correlation, Path analysis Discriminate function and principal component analysis, Genetic divergence analysis- Metroglyph and D2, Generation mean analysis, Parent progeny regression analysis

Unit IV

Mating designs- classification, Diallel, partial diallel, $L \times T$, NCDs, and TTC; Concept of combining ability and gene action, $G \times E$ interaction-Adaptability and stability; Methods and models for stability analysis; Basic models- principles and interpretation, Bi-plot analysis, AMMI analysis.

Unit V

QTL mapping, Strategies for QTL mapping- Desired population and statistical methods, QTL mapping in genetic analysis; Markers, Marker assisted selection and factors influencing the MAS, Simultaneous selection based on marker and phenotype.

Practical

- Analysis and interpretation of variability parameters;
- Analysis and interpretation of Index score and Metroglyph;
- Clustering and interpretation of D2 analysis;
- Genotypic and phenotypic correlation analysis and interpretation;
- Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation;
- A, B and C Scaling test;
- $L \times T$ analysis and interpretation, QTL analysis;
- Use of computer packages;
- Diallel analysis;
- $G \times E$ interaction and stability analysis.
- Use of R studio for biometrical trait analysis

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures,

- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

After studying this course, the student will be equipped with the knowledge of additive dominance and epistatic gene action. He will also be introduced with the various designs for analysis of genotypic and phenotypic variance and QTL mapping.

Suggested Reading

Bos I and Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
 Falconer DS and Mackay J. 1998. *Introduction to Quantitative Genetics* (3rd Ed.). ELBS/Longman, London.
 Mather K and Jinks JL. 1985. *Biometrical Genetics* (3rd Ed.). Chapman and Hall, London.
 Nandarajan N and Gunasekaran M. 2008. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.
 Naryanan SS and Singh P. 2007. *Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.
 Roy D. 2000. *Plant Breeding: Analysis and Exploitation of Variation*. Narosa Publishing House, New Delhi.
 Sharma JR. 2006. *Statistical and Biometrical Techniques in Plant Breeding*. New Age International Pvt. Ltd.
 Singh P and Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.
 Singh RK and Chaudhary BD. 1987. *Biometrical Methods in Quantitative Genetic analysis*. Kalyani Publishers, New Delhi.
 Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
 Wricke G and Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

e-Suggested Reading

www.iasri.icar.gov.in
www.hau.ac.in/OPstat

Why this course?

The course will provide deep knowledge to the students on genotyping and kinds of markers including biochemical and molecular, mapping populations, allele mining. This will also add ways to perform marker-assisted selection and gene pyramiding to evolve superior varieties.

Aim of the course

To impart knowledge and practical skills to use innovative approaches and Bioinformatics in Plant Breeding.

Theory**Unit I**

Genotyping; Biochemical and Molecular markers; Morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs, etc.), Functional markers; Mapping populations (F₂s, back crosses, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits; Statistical tools in marker analysis.

Unit II

Allele mining; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants; Marker-assisted backcross breeding for rapid introgression; Genomics- assisted breeding; Generation of EDVs; Gene pyramiding.

Unit III

Introduction to Comparative Genomics; Large scale genome sequencing strategies; Human genome project; Arabidopsis genome project; Rice genome project; Comparative genomics tools; Introduction to proteomics; 2D gel electrophoresis; chromatography and sequencing by Edman degradation and mass spectrometry; Endopeptidases; Nanotechnology and its applications in crop improvement.

Unit IV

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer; Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, vegetable, flower, fruit, spice, plantation, medicinal, aromatic crops etc. and commercial releases; Biotechnology applications in male sterility/ hybrid breeding, molecular farming; Application of Tissue culture in molecular breeding; MOs and related issues (risk and regulations); GMO; International regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights; Introduction to bioinformatics: bioinformatics tools, biological data bases (primary and secondary), implications in crop improvement.

Practical

- Requirements for plant tissue culture laboratory;
- Techniques in plant tissue culture;
- Media components and media preparation;
- Aseptic manipulation of various explants, observations on the contaminants occurring in media, interpretations;
- Inoculation of explants, callus induction and plant regeneration;
- Standardizing the protocols for regeneration;
- Hardening of regenerated plants; Establishing a greenhouse and hardening procedures;
- Visit to commercial micropropagation unit;
- Transformation using Agrobacterium strains;
- GUS assay in transformed cells/ tissues;
- DNA isolation, DNA purity and quantification tests;
- Gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship;
- Visit to commercial genetic engineering laboratory;
- Construction of genetic linkage maps using computer software;
- NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p, Gene Prediction Tool;

- Expasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder;
- Comparative Genomic Resources: - Map Viewer (UCSC Browser and Ensembl);
- Primer designing- Primer 3/ Primer BLAST.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning Outcome

The knowledge of this course will enable the student to know about various molecular tools and approaches for genotyping and marker assisted breeding, intellectual property rights, bioinformatics tools and their uses in crop improvement.

Suggested Reading

- Azuaje F and Dopazo J. 2005. *Data Analysis and Visualization in Genomics and Proteomics*. John Wiley and Sons.
- Brown TA. 1991. *Essential Molecular Biology: a practical Approach*. Oxford university press, 2002, 2nd edition
- Chawala HS. 2000. *Introduction to Plant Biotechnology*. Oxford & IBH Publishing Co. Pvt. Ltd.
- Chopra VL and Nasim A. 1990. *Genetic Engineering and Biotechnology: Concepts, Methods and Applications*. Oxford & IBH.
- Gupta PK. 1997. *Elements of Biotechnology*. Rastogi Publ.
- Hackett PB, Fuchs JA and Messing JW. 1988. *An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation*. 2nd Ed. Benjamin Publ. Co.
- Jollès P and Jörnvall H. 2000. *Proteomics in Functional Genomics: Protein Structure Analysis*. Birkhäuser.
- Lewin B. 2017. *Genes XII*. Jones & Bartlett learning, 2017.
- Robert NT and Dennis JG. 2010. *Plant Tissue Culture, Development, and Biotechnology*. CRC Press.
- Sambrook J and Russel D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Lab. Press.
- Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani Publishers, New Delhi.
- Watson J. 2006. *Recombinant DNA*. Cold Spring harbor laboratory press.

Why this course?

Quality consciousness is growing in the society and only quality products are in demand in the market so has to be the new varieties. This course acquaints breeding for grain quality parameters in field crops. It will also teach about the genetic engineering protocols for quality improvement: Biofortification in crops and Nutritional genomics and Second generation transgenics.

Aim of the course

To provide insight into recent advances in improvement of quality traits in cereals, millets, legumes, oilseeds, forage and industrial crops using conventional and modern biotechnological approaches.

Theory**Unit I**

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors; Nutritional improvement - A human perspective.

Unit II

Breeding for grain quality parameters in rice and its analysis; Golden rice and aromatic rice: Breeding strategies, achievements and application in Indian context; Molecular basis of quality traits and their manipulation in rice; Post harvest manipulation for quality improvement; Breeding for baking qualities in wheat, characters to be considered and breeding strategies, molecular and cytogenetic manipulation for quality improvement in wheat.

Unit III

Breeding for quality improvement in Sorghum, pearl millet, barley and oats; Quality protein maize, specialty corns, concept and breeding strategies; Breeding for quality improvement in important forage crops for stay green traits; Genetic resource management for sustaining nutritive quality in crops.

Unit IV

Breeding for quality improvement in pulses – Chickpea, pigeonpea, green gram and black gram cooking quality; Breeding for quality in oilseeds -groundnut, mustard, soybean, sesame, sunflower and minor oilseeds; Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality improvement in cotton. Breeding for quality improvement in Sugarcane, potato.

Unit V

Genetic engineering protocols for quality improvement: Achievements made; Biofortification in crops; Classification and importance, Nutritional genomics and Second generation transgenics.

Practical

- Grain quality evaluation in rice; Correlating ageing and quality improvement in rice;
- Quality analysis in millets;
- Estimation of anti-nutritional factors like tannins in different varieties/ hybrids: A comparison;
- Quality parameters evaluation in wheat, pulses and oilseeds;
- Evaluation of quality parameters in cotton, sugarcane and potato;
- Value addition in crop plants;
- Post-harvest processing of major field crops;
- Quality improvement in crops through tissue culture techniques;
- Evaluating the available populations like RIL, NIL, etc. for quality improvement using MAS procedures;
- Successful example of application of MAS for quality trait in rice, mustard, maize, etc.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments

- Quiz
- Group tasks, student's presentations

Learning outcome

The knowledge of this course will expose the student to know about various conventional and genetic engineering techniques for the improvement of quality characters in agricultural and horticultural field crops.

Suggested Reading

Chahal GS and SS Ghosal. 2002. *Principles and procedures of plant breeding – Biotechnological and Conventional approaches*, Narosa Publications
 Chopra VL. 1997. *Plant Breeding*. Oxford & IBH. 2018.
 FAO 2001. *Speciality Rices of the World - Breeding, Production and Marketing*. Oxford & IBH, 1 Nov 2001.
 Ghosh P. 2004. *Fibre Science and Technology*. Tata McGraw Hill.
 Gupta SK. 2007. *Advances in Botanical Research* Vol. 45 Academic Press USA.
 Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.
 Nigam J. 1996. *Genetic Improvement of Oilseed Crops*. Oxford & IBH.
 Singh BD. 1997. *Plant Breeding*. Kalyani Publishers, New Delhi.
 Singh RK, Singh UK and Khush GS. 2000. *Aromatic Rices*. Oxford & IBH.

Why this course?

This course will expose the students with the basic concepts of hybrid varieties and various techniques for development of hybrids in crop plants. This will also give an overview of various kinds of male sterility and their utilization in hybrid seed production of important field crops.

Aim of the course

To provide knowledge of understanding about mechanisms of heterosis and its exploitation for yield improvement through conventional and biotechnological approaches.

Theory**Unit I**

Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Evolutionary aspects – Genetic consequences of selfing, sibbing and crossing in self- and cross-pollinated and asexually propagated crops; Pre-Mendelian and Post-Mendelian ideas – Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical basis of heterosis.

Unit II

Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F₂ and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.; Relationship between genetic distance and expression of heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/ genetic stocks and inbreds, their improvement for increasing heterosis.

Unit III

Male sterility and use in heterosis breeding; Male sterile line creation and diversification in self-pollinated, cross pollinated and asexually propagated crops; Creation of male sterility through genetic engineering and its exploitation in heterosis; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids.

Unit IV

Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis, maintenance breeding of parental lines in hybrids; Fixation of heterosis in self, cross and often cross pollinated crops, asexually/ clonally propagated crops, problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid; Organellar heterosis and complementation.

Unit V

Hybrid breeding in wheat, rice, cotton, maize, pearl millet, sorghum, rapeseed mustard, sunflower, safflower, castor, other oilseed crops, pigeonpea, vegetable, fruit, ornamental, medicinal, spice, aromatic and plantation crops.

Practical

- Characterization of male sterile lines using morphological descriptors;
- Restorer line identification and diversification of male sterile sources;
- Male sterile line creation in crop plants, problems in creation of CGMS system, ways of overcoming them;
- Diversification and restoration;
- Success stories of hybrid breeding in Maize, Rice, pearl millet, Sorghum, Pigeon pea, vegetable, fruit, ornamental, medicinal, spice, aromatic and plantation crops
- Understanding the difficulties in breeding apomicts;
- Estimation of heterotic parameters in self, cross and asexually propagated crops;
- Estimation from the various models for heterosis parameters;

- Hybrid seed production in field crops—an account on the released hybrids, their potential, problems and ways of overcoming it;
- Hybrid breeding at National and International level, opportunities ahead.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

After completing this course, the student will be able to know about importance of heterosis, the various conventional and biotechnological approaches for the development of hybrids. This will also enable student to know about the use of male sterility in hybrid seed production of important field crops.

Suggested Reading

- Agarwal RL. 1998. *Fundamental of Plant Breeding and hybrid Seed Production*. Science Publisher London.
- Akin E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.
- Ben HL. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.
- Chal GS and Gossal SS. 2002. *Principles and procedures of Plant Breeding, Biotechnology and Convetional Approaches*. Narosa Publishing House. New Delhi
- De JG. 1988. *Population Genetics and Evolution*. Springer-Verlag. 30 January 2012
- Hartl DL. 2000. *A Primer of Population Genetics*. 3rd Ed. Sinauer Assoc.
- Mettler LE and Gregg TG. 1969. *Population Genetics and Evolution*. Prentice-Hall. 25 April 1988
- Montgomery DC. 2001. *Design and Analysis of Experiments*. 5th Ed., Wiley & Sons. 2013
- Mukherjee BK. 1995. *The Heterosis Phenomenon*. Kalyani Publishers, New Delhi.
- Proceedings of *Genetics and Exploitation of Heterosis in Crops – An International Symposium CIMMYT*, 1998.
- Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin. 30 May 1997
- Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.
- Srivastava S and Tyagi R. 1997. *Selected Problems in Genetics*. Vols. I, II. Anmol Publ.
- Virmani SS. 1994. *Heterosis and Hybrid Rice Breeding. Monographs of "Theoretical and Applied Genetics"*, Springer-Verlag.

Why this course?

Climate change is a big challenge to sustain higher crop productivity and nutritional quality. Concept of breeding for stress tolerance and development of hybrids/varieties for climate change is of prime importance in plant breeding. Therefore this course is essential for budding plant breeders.

Aim of the course

To apprise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress tolerant varieties.

Theory**Unit I**

Concept and impact of climatic change; Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses – major pests and diseases of economically important crops.

Unit II

Concepts of resistance to insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defence mechanisms against viruses and bacteria.

Unit III

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants; Quantitative resistance/ adult plant resistance and slow rusting resistance; Classical and molecular breeding methods – Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications. Classification of abiotic stresses - Stress inducing factors, moisture stress/ drought and water logging and submergence; Acidity, salinity/ alkalinity/ sodicity; High/low temperature, wind, etc.; Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

Unit IV

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging and submergence, high and low/freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton, etc.; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/ contaminants in soil, water and environment.

Unit V

Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management. Achievements in biotic and abiotic stress resistance breeding.

Practical

- Understanding the climatological parameters and predisposal of biotic and abiotic stress factors- ways of combating them for diseases caused by fungi and bacteria;
- Symptoms and data recording; use of MAS procedures;
- Phenotypic screening techniques for sucking pests and chewing pests – Traits to be observed at plant and insect level;
- Phenotypic screening techniques for nematodes and borers; Ways of combating them;
- Evaluating the available populations like RIL, NIL, etc. for pest resistance;
- Use of standard MAS procedures. Breeding strategies - Weeds – ecological, environmental impacts on the crops;
- Breeding for herbicide resistance;
- Screening crops for drought and flood resistance; factors to be considered and breeding strategies;

- Screening varieties of major crops for acidity and alkalinity- their effects and breeding strategies;
- Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

After completion of this course the student will be able to well verse with the stress and its causes. This will enable the students for the development of RIL, NIL, etc. for pest resistance and Use of standard MAS procedures

Suggested Reading

- Blum A. 1988. *Plant Breeding for Stress Environments*. CRC Press.
- Christiansen MN and Lewis CF. 1982. *Breeding Plants for Less Favourable Environments*. Wiley International.
- Fritz RS and Simms EL. (Eds.). 1992. *Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics*. The University of Chicago Press.
- Li PH and Sakai A. 1987. *Plant Cold Hardiness*. Liss, New York Springer
- Luginpill P. 1969. *Developing Resistant Plants - The Ideal Method of Controlling Insects*. USDA, ARS, Washington DC.
- Maxwell FG and Jennings PR. (Eds.). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons. Wiley-Blackwell.
- Roberto F. 2018. *Plant Breeding for Biotic and Abiotic Stress Tolerance*. Springer.
- Russel GE. 1978. *Plant Breeding for Pest and Disease Resistance*. Butterworths.
- Sakai A and Larcher W. 1987. *Frost Survival in Plants*. Springer-Verlag.
- Singh BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.
- Turener NC and Kramer PJ. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons.
- van der Plank JE. 1982. *Host-Pathogen Interactions in Plant Disease*. Academic Press.

Ph.D. Courses

GPB601 ADVANCES IN PLANT BREEDING SYSTEMS (3+0)

Why this course?

This course is an advancement of principles, various plant breeding methodologies and procedures in the development of a complex population; MAS for selection of qualitative and quantitative traits, Gene pyramiding, marker-based utilization of exotic Germplasm and introgression libraries.

Aim of the course

To impart theoretical knowledge about advances in plant breeding.

Theory

Unit I

Advances in reproductive biology of crops; Genes governing the whorls formation and various models proposed; Pollen pistil interaction: biochemical and molecular basis, environmental factors governing anthesis and bottlenecks for gene transfer.

Unit II

Plant Breeding methodologies: Classic versus modern; Over view of Pre and Post Mendelian breeding methods in self and cross pollinated crops; Molecular and transgenic breeding approaches; doubled haploid breeding, shuttle breeding, forward and reverse breeding, speed breeding, participatory plant breeding, breeding for organic situations.

Unit III

Principles and procedures in the formation of a complex population; Genetic basis of population improvement in crop plants; Recurrent selection methods in self and cross pollinated crops and their modifications; Convergent selection, divergent selection; Recurrent selection, usefulness in hybrid breeding programs; Reciprocal recurrent selection; Selection in clonally propagated crops – Assumptions and realities.

Unit IV

Choice of molecular markers for plant breeding efficiency, fingerprinting and genetic diversity assessment, application of MAS for selection of qualitative and quantitative traits; Gene pyramiding, accelerated backcrossing, marker-based utilization of exotic germplasm, introgression libraries.

Unit V

Genetic resources: primary, secondary, tertiary and alien trans gene pool; Molecular and biochemical basis of self-incompatibility and male sterility, nucleocytoplasmic interactions with special reference to male sterility – genetic, biochemical and molecular bases.

Unit VI

Genetic engineering technologies to create male sterility, prospects and problems, use of self-incompatibility and sterility in plant breeding – case studies; Fertility restoration in male sterile lines and restorer diversification programs; Conversion of agronomically ideal genotypes into male sterile: Concepts and breeding strategies; Case studies - Generating new cyto-nuclear interaction system for diversification of male sterile; Stability of male sterile lines – Environmental influence on sterility, Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding; Temperature sensitive genetic male sterility and its use heterosis breeding; Apomixis and its use in heterosis breeding; Incongruity: Factors influencing incongruity Methods to overcome incongruity mechanisms.

Unit VII

Breeding for climate change -Improving root systems, abiotic stress tolerance, water use efficiency, flooding and sub-mergence tolerance; Biotic stress tolerance; Nutrient use efficiency, nitrogen fixation and assimilation, greenhouse gases and carbon sequestration; Breeding for bio-fortification.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

After completion of this course the student will be able to know various plant breeding methodologies, principles and procedures for the formation of a complex population; MAS for selection of qualitative and quantitative traits, Gene pyramiding, marker based utilization of exotic Germplasm and Breeding for climate change

Suggested Reading

- Agarwal RL. 1996. *Fundamentals of Plant Breeding and Hybrid Seed Production*. Oxford & IBH.
- Allard RW. 1966. *Principles of Plant Breeding*. John Wiley & Sons.
- Briggs FN and Knowles PF. 1967. *Introduction to Plant Breeding*. Reinhold.
- Fehr WR. 1987. *Principles of Cultivar Development: Theory and Technique*. Vol I. Macmillan.
- Hayes HK, Immer FR and Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.
- Kang MS and Priyadarshan PM (Edit.). 2007. *Breeding Major Food Staples*. Blackwell Publishing.
- Kole C. 2013. *Genomics and Breeding for Climate-Resilient Crops*. Springer. Volume 2-Target Traits.
- Mandal AK, Ganguli PK and Banerji SP. 1995. *Advances in Plant Breeding*. Vol. I, II. CBS.
- Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.
- Sharma JR. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
- Simmonds NW. 1979. *Principles of Crop Improvement*. Longman.
- Singh BD. 1997. *Plant Breeding: Principles and Methods*. 5th Ed., Kalyani Publishers, New Delhi.
- Singh P. 1996. *Essentials of Plant Breeding*. Kalyani Publishers, New Delhi.
- Welsh JR. 1981. *Fundamentals of Plant Genetic and Breeding*. John Wiley.

Why this course?

This course is essential to understand various qualitative, quantitative systems/techniques related to genetic improvement of crops, G x E Interaction, Construction of saturated linkage maps and Marker Assisted Selection (MAS).

Aim of the course

To impart theoretical knowledge and computation methods for non-allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory**Unit I**

Continuous variation-evolutionary studies; Genetic principles of continuous variation, Qualitative and quantitative techniques-differences, population types, approaches; various types of metrics, F₂, F and mixed; Selection of parents Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes.

Unit II

Components of mean- Additive effect, breeding value, coefficient of gene dispersion, dominance; Simple scaling test, expectation of mean of character in various types of families in coupling and dispersed phase; Epistasis-Specification, weighted and un-weighted joint scaling test; Effect of linkage to generation mean, specification of mean to G × E interaction.

Unit III

Component of variances-advantages, variances of different generations, balance sheet of variance; estimation of parameters-weighted and unweighted, least square analysis; random mating population; experimental population-BIPs, NCD-I, II, III, Triple test cross for random mating population and inbreds; Estimates of linkage and non-allelic interactions; Combining ability analysis, Hayman's Approach.

Unit IV

G × E Interaction, stability and adaptability; Advanced models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Merits and limitation of different stability analysis methods; Analysis and selection of genotypes; Methods and steps to select the best model - Biplots and mapping genotypes.

Unit V

Construction of saturated linkage maps, concept of framework map development; QTLs-different types of markers and mapping populations, linkage maps, mapping-Strategies for QTL mapping - desired populations, statistical methods; MAGIC populations, Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on markers - simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods; Use of advanced software packages for biometrical analysis, interpretation of analysed data.

Practical

- Generation mean analysis: ABC scaling test and Joint scaling test- Analysis and interpretation;
- Estimation of variance of different filial generations and interpretations;
- Diallel analysis: Numerical, graphical and combining ability analysis; Trialallel analysis;
- NC Designs: Triple test cross analysis;
- Stability analysis: Eberhart and Russel model;
- AMMI model - Principal Component Analysis model - Additive and multiplicative model – Shifted multiplicative model - Analysis and selection of genotypes – Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes;
- Construction of linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping;
- Phenotype and Marker linkage studies;

- Use of advanced software in biometrical analysis.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

After the completion of this course student will be able to understand various Qualitative and quantitative techniques, G x E Interaction, Construction of saturated linkage maps and Marker Assisted Selection, Use of advanced software packages for biometrical analysis, interpretation of analysed data.

Suggested Reading

- Bos I and Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
- Dabholkar AR. 1993. *Elements of Biometrical Genetics*. Concept Publishing Co. New Delhi.
- Falconer DS and Mackay J. 1996. *Introduction to Quantitative Genetics* (4 Ed.). ELBS/ Longman, London.
- Mather K and Jinks JL. 1985. *Biometrical Genetics* (3rd Ed.). Chapman and Hall, London.
- Nandarajan N and Gunasekaran M. 2008. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.
- Roy D. 2000. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publishing House, New Delhi.
- Singh P and Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.
- Singh RK and Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani Publishers, New Delhi.
- Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
- Wricke G and Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

Why this course?

The knowledge of recent trends in plant genomics, genome sequencing, molecular maps, and concepts of high-throughput proteomics, metabolomics and phenomics is essential in rapid crop improvement programmes.

Aim of the course

To impart practical skills in advanced molecular techniques in genome mapping structural/ functional genomics.

Theory**Unit I**

Introduction to the plant genomes: nuclear, chloroplast and mitochondrial genomes; Concept of genome size and complexity: C-value paradox, repetitive and unique DNA.

Unit II

Genome sequencing: Principles and techniques of conventional approaches and next generation sequencing including sequencing-by-synthesis/ ligation and single molecule real time (SMRT) technologies; Applications of sequence information: structural, functional and comparative genomics; Plant genome projects: Strategies for genome sequencing including shot gun and clone-by-clone method.

Unit III

Molecular maps: Use of molecular markers/ SNPs for development of genetic and physical maps; Linkage and LD-based gene mapping approaches including gene/QTL mapping, genome wide association studies (GWAS) and association analysis; Integration of genetic and physical map for map-based cloning of economically important genes. Concept of allele mining; Diversity array technology: concepts and applications.

Unit IV

Functional genomics: concept of reverse and forward genetics; Use of activation tagging, transposon tagging, insertional mutagenesis, TILLING and ecoTILLING for crop improvement; Genome-wide and gene-specific transcriptomics approaches: serial analysis of gene expression, massively parallel signature sequencing, next generation sequencing, microarray, northern hybridization, RT-PCR, qRT-PCR and molecular beacon.

Unit V

Development and management of database; Applications of bioinformatics tools/software in genomics for crop improvement. Basic concepts of high-throughput proteomics, metabolomics and phenomics.

Unit VI

Recent transgene free genome editing tools such as CRISPR-Cas9 system, TALENS and ZFNs for crop improvement. Cisgenesis and Intragenesis tools as twin sisters for Crop Improvement; Genomics-based plant breeding: Genome-Wide Genetic Diversity Studies, Identification of molecular markers linked to single Genes and QTL, Marker Assisted Selection (Marker Assisted Backcross Selection, Association mapping, Breeding by Design, Genome selection).

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

After the completion of this course, the student will have expertise on about different techniques for genome sequencing, molecular maps, and concepts of high-throughput proteomics, metabolomics and phenomics in crop improvement

Suggested Reading

- Alonso JM, Stepanova AN. 2015. *Plant Functional Genomics: Methods and Protocols*. Springer.
- Chopra VL, Sharma RP, Bhat SR and Prasanna BM. 2007. *Search for New Genes*. Academic Foundation, New Delhi.
- Hackett PB, Fuchs JA and Messing JW. 1988. *An Introduction to Recombinant DNA Technology— Basic Experiments in Gene and Manipulation*. 2nd Ed. Benjamin Publication Co.
- Primose SB and Twyman RM. 2006. *Principles of Gene Manipulation and Genomics*. 7th Ed. Wiley-Blackwell Publishing.
- Sambrook J and Russel D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Laboratory Press.
- Singh BD. 2005. *Biotechnology: Expanding Horizons*. Kalyani Publishers, New Delhi.
- Somers DJ, Langridge P, Gustafson JP. 2009. *Plant Genomics: Methods and Protocols*. Springer.

e-Resources

- <http://gramene.org>
- <https://www.arabidopsis.org>
- <https://wheat.pw.usda.gov>
- <http://ncbi.nlm.nih.gov>
- <http://www.maizegenetics.net>

Why this course?

This course imparts knowledge about the origin and evolution of species, centres of diversity, speciation, domestication and significance of polyploidy.

Aim of the course

To impart knowledge on crop evolutionary aspects and role of mutations, hybridizations and polyploidy in crop evolution and improvement.

Theory**Unit I**

Origin and evolution of species; Centres of diversity/ origin, diffused centres; Time and place of domestication; Patterns of evolution and domestication-examples and Case studies; Domestication and uniformity–characteristics of early domestication and changes – Concept of gene pools and crop evolution; Selection and Genetic drift – Consequences.

Unit II

Speciation and domestication–The process of speciation, Reproductive isolation barriers; Genetic differentiation during speciation; Hybridization - speciation and extinction; Exploitation of natural variation: Early attempts to increase variation, Distant hybridization and introgression, Inter-specific, inter-generic hybridization, scope and limitations, techniques to overcome the limitations; Gene transfer into cultivated species, tools and techniques; Validation of transferred genes and their expression; Controlled introgressions.

Unit III

Processes in crop evolution and stabilization of polyploids, cytogenetic and genetic stabilization; Genome organization – Transgenesis in crop evolution, Multifactorial genome, Intragenomic interaction, Intergenic interaction, Genome introgression; Methods to study crop evolution - Contemporary Methods, Based on morphological features, Cytogenetic analysis, Allozyme variations and crop evolution, DNA markers, genome analysis and comparative genomics.

Unit IV

Evolutionary significance of polyploidy, evolution of crop plants through ploidy manipulations; Polyploids: methods, use of autopolyploids; haploidy and DH-method of production and use, allopolyploids; synthesis of new crops; Case studies – Cereals, Pulses, Oilseeds, Fibre crops, vegetables, fruits, flowers, Plantation crops, Forage crops, Tuber crops, Medicinal and aromatic crop Plants.

Teaching methods

- Power point presentation
- Chalk and Board
- Smart board
- Lectures
- Assignments, quiz
- Group tasks, student's presentations

Learning outcome

After the completion of this course the student will have knowledge of Origin and evolution of species, Centres of diversity, Speciation, domestication and significance of micro-mutations and polyploidy in genetic improvement of crop plants.

Suggested Reading

- Hancock JF. 2004. *Plant Evolution and the Origin of Crop Species*. 2nd Ed. CABI.
- Ladizinsky G. 1999. *Evolution and Domestication*. Springer.
- Miller AJ. 2007. *Crop Plants: Evolution*. John Wiley & Sons.
- Smartt J and Simmonds NW. 1995. *Evolution of Crop Plants*. Blackwell.

D. PLANTPHYSIOLOGY

M.Sc. (Hort.) Syllabus

PP 501PRINCIPLES OF PLANT PHYSIOLOGY I - PLANT WATER RELATIONS AND MINERAL NUTRITION (2+1)

Why this Course?

Plant's growth and development and therefore, agricultural productivity depends on two major inputs like water and nutrients. In this regard, this course being a fundamental course will acquaint the students with the basic concepts of plant water relations and mineral nutrition. The course provides a basic knowledge on water and nutrient acquisition and their transport throughout the phenological stages. Further, it also provides hands on experience in assessing the plant and soil water status besides nutrient acquisition by plants.

Aim of the Course

The aim of this course is to impart knowledge in the field of water relations and mineral nutrition and how plants acquire water and transport it under different soil water regimes and also make use of the water in an effective way to maximize use efficiency. In addition, the other aim is to impart knowledge of how plants minimize water loss under stress conditions besides educating the students of how plants make use of nutrients in a best possible way. The course is organized as follows:

No.	Blocks	Units
1.	Plant Water Relations	1. Soil and Plant Water Relations 2. Water Absorption and Translocation 3. Transpiration and Evaporative Cooling 4. Water Productivity and Water Use Efficiency 5. Moisture Stress and Plant Growth
2.	Mineral Nutrition	1. Nutrient Elements and their Importance 2. Nutrient Acquisition 3. Concept of Foliar Nutrition

Theory

Block 1: Plant Water Relations

Unit 1: Soil and Plant Water Relations

Water and its importance; Molecular structure of water; Properties and functions of water. Concept of water potential; Plant cell and soil water potential and their components; Methods to determine cell and soil water potential; Concept of osmosis and diffusion. Soil physical properties and water availability in different soils; Water holding capacity and approaches to improve WHC; Concept of FC and PWP; Water holding polymers and their relevance.

Unit 2: Water Absorption and Translocation

Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation; Theories explaining water absorption and translocation; Aquaporins. Mycorrhizal association and its relevance in water mining.

Unit 3: Transpiration and Evaporative Cooling

Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance. Energy balance: Solar energy input and output at crop canopy level. Stomata- its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure. Antitranspirants and their relevance in agriculture.

Unit 4: Water Productivity and Water Use Efficiency

WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE.

Unit 5: Moisture Stress and Plant Growth

Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level. Drought indices and drought tolerance strategies. Drought tolerance traits.

Block 2: Mineral Nutrition

Unit 1: Nutrient Elements and Their Importance

Role of mineral nutrients in plant's metabolism; Essential elements and their classification; Beneficial elements; factors influencing the nutrients availability; critical levels of nutrients. Functions of mineral elements in plants. Deficiency and toxicity symptoms in plants.

Unit 2: Nutrient Acquisition

Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters; xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels. Role of mycorrhiza, root exudates and PGPRs in plant nutrient acquisition.

Unit 3: Concept of Foliar Nutrition

Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.

VII. Practicals

- Standard solutions and preparation of different forms of solutions
- Studies on the basic properties of water
- Demonstration of surface tension of water and other solvents
- Measurement of plant water status: Relative water content and rate of water loss
- Determination of water potential through tissue volume and Chardakov's test
- Determination of water potential using pressure bomb, osmometer, psychrometer
- Determination of soil moisture content and soil water potential
- Use of soil moisture probes and soil moisture sensors
- Measurement of transpiration rate in plants; use of porometry
- Measurement of CCATD and its relevance
- Demonstration and use of anti-transpirants to reduce transpiration
- Influence of potassium and ABA on stomatal opening and closing respectively
- Deficiency and toxicity symptoms of nutrients
- Effect of water stress on plant growth and development

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation
- Practicals

Learning outcome

By the end of this course, the student will be able to:

- comprehend the fundamental concepts of plant physiological processes associated with water relation and mineral nutrition.
- describe the physiological mechanisms of water relation and mineral nutrition.
- recognize and describe how plants respond to mineral deficiency and toxicity.

Suggested Reading

Vilalta JM and Forner NG. 2017. *Water potential regulation, stomatal behaviour and hydraulic transport under drought: deconstructing the iso/anisohydric concept* Plant, Cell and Environment 40, 962–976
Mangrich AS, Cardoso EMC, Doumer ME, Romão LPC, Vidal M, Rigol A, Novotny EH. *Improving the Water Holding Capacity of Soils of Northeast Brazil by Biochar Augmentation*. Chapter 16, pp 339–354.

McElrone AJ, Choat B, Gambetta GA and Brodersen CR. 2013. *Water Uptake and Transport in Vascular Plants*. *Nature Education Knowledge* 4(5): 6

Hodson RC and J Acuff. 2006. *Water transport in plants: anatomy and physiology*. Pages 163-183, *Tested Studies for Laboratory Teaching*, Volume 27 (M.A. O'Donnell, Editor). Proceedings of the 27th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 383 pages.

Chater CCC, Caine RS, Fleming AJ, Gray JE. 2017. *Plant Physiology*, 174 (2) 624-638; DOI: 10.1104/pp.17.00183

Dietrich P, Sanders D, Hedrich R. 2001. *The role of ion channels in light dependent stomatal opening*, *Journal of Experimental Botany*, Volume 52, Issue 363, Pages 1959–1967, <https://doi.org/10.1093/jexbot/52.363.1959>

Sreeman SM, Vijayaraghavareddy P, Sreevathsa R, Rajendrareddy S, Arakesh S, Bharti P, Dharmappa P, Soolanayakanahally R. 2018. *Introgression of Physiological Traits for a Comprehensive Improvement of Drought Adaptation in Crop Plants*. *Front. Chem.* 6, 92.

Seyed Yahya Salehi-Lisar Hamideh Bakhshayeshan-Agdam, (2016). Drought Stress in Plants: Causes, Consequences, and Tolerance. *Drought Stress Tolerance in Plants*, Vol 1 pp 1-16

Pandey R. 2015. *Mineral Nutrition of Plants*. 10.1007/978-81-322-2286-6_20.

Barker AV and DJ Pilbeam. 2015. *Handbook of Plant Nutrition*, Second Edition. Books in Soils, Plants, and the Environment Series, the 2nd Edition, CRC Press.

Vatansever R, Ozyigit II and Filiz E. 2017. *Essential and beneficial trace elements in plants, and their transport in roots: a review*. *Applied biochemistry and biotechnology* 181(1), 464-482.

Tahat MM and Sijam K. 2012. *Arbuscularmycorrhizal fungi and plant root exudates biocommunications in the rhizosphere*. *African Journal of Microbiology Research*, 6(46), 7295-7301.

Rajasekar MD, Nandhini DU and Suganthi S. 2017. *Supplementation of Mineral Nutrients through Foliar Spray – A Review*. *Int.J.Curr.Microbiol.App.Sci.* 6(3): 2504-2513.<https://doi.org/10.20546/ijcmas.2017.603.283>

Tarek A and Hassan ER. 2017. *Foliar application: from plant nutrition to biofortification*. *Environment, Biodiversity and Soil Security*. 10.21608/jenvbs.2017.1089.1006.

General Source of Information

Taiz T, Zeiger E and Max Mller IM, 2018, *Fundamentals of Plant Physiology*

Taiz L and Zeiger E. 2015. *Plant Physiology and development*. 6th Ed

Salisbury FB and Ross C. 1992 (4th Ed.) *Plant Physiology*

Epstein E and Bloom AJ. 2004. *Mineral nutrition of plants: principles and perspectives*. 2nd Ed.

Hopkins WG and Huner NPA. 2004. *Introduction to Plant Physiology*

Kramer, P. J., *Water relations of plants*

Kirkham, M. B., *Principles of soil and plant water relations*

Hopkins WG, 2008, *Introduction to Plant Physiology*

PP 502 PRINCIPLES OF PLANT PHYSIOLOGY-II: METABOLIC PROCESSES AND GROWTH REGULATION

(2+1)

Why this course?

Mechanisms associated with growth and development determine crop performance under any given condition. Metabolic and growth processes are quite sensitive to environmental factors and hence comprehensive understanding of the physiological basis of growth and development would be essential.

Aim of the course

This course will impart knowledge on cellular structure and function that determine of carbon and nitrogen metabolism, lipids, enzymes and secondary metabolites in plants. Relevance of metabolic processes on growth and development leading to productivity will be dealt.

The course is organized as follows:

No.	Blocks	Units
1.	Metabolic processes and growth	1. Carbon Metabolism–Photochemical Processes regulation 2. Carbon Metabolism: Biochemical Processes 3. Carbon Metabolism: Respiration 4. Product Synthesis and Translocation Leading to Crop Growth 5. Nitrogen Assimilation and Protein Synthesis 6. Lipid Metabolism and Secondary Metabolites 7. Hormonal Regulation of Plant Growth and Development 8. Synthetic Growth Promoters 9. Morphogenesis and Reproductive Phase

Theory

Block 1: Metabolic Processes and Growth Regulation

Unit 1: Carbon Metabolism – Photochemical Processes

Chloroplast ultrastructure with special mention of lamellar system; Excitation, electron and proton transfers and their relevance in energy conservation; Concepts of pigment systems and generation of powerful reductant and oxidant; Water oxidation, Water-water cycle and other aspects of electron transfer

Unit 2: Carbon Metabolism: Biochemical Processes

CO₂ diffusion mechanisms and diffusive conductances, concept of C_i determining Photosynthesis; RuBisCO enzyme kinetics and Calvin cycle mechanisms, Regulation of Calvin cycle and metabolite fluxes; Photorespiration: the advantages and inefficiencies of photosynthesis because of photorespiration; Concepts of CO₂ concentrating mechanisms (CCM) and spatial and temporal differences in carboxylation; Ecological aspects of C₄ and CAM photosynthesis; Product synthesis, Starch and Sucrose biosynthesis

Unit 3: Carbon Metabolism: Respiration

Mitochondrial organization and functions; Aspects of Glycolysis, TCA cycle and mitETC.; Relevance of growth and maintenance respiration; Concepts of CN resistance respiration – Alternate and SHAM sensitive ETC

Unit 4: Product Synthesis and Translocation Leading to Crop Growth

Phloem loading and sugar transporting, concepts of bi-directional transport of sugars and other metabolites Source-Sink relationship and modulation of photosynthesis; Concepts and definitions of Growth and Differentiation; Growth and yield parameters, NAR, CGR, HI and concepts of LAI, LAD

Unit 5: Nitrogen Assimilation and Protein Synthesis

Developments in d-nitrogen fixation; Nitrate reduction and assimilation GS-GOGAT process for amino acid synthesis; Inter-Dependence of carbon assimilation and nitrogen metabolisms

Unit 6: Lipid Metabolism and Secondary Metabolites

Storage, protective and structural lipids.; Biosynthesis of fatty-acids, diacyl and triacyl glycerol, fatty acids of storage lipids.; Secondary metabolites and their significance in plant defense mechanisms.

Unit 7: Hormonal Regulation of Plant Growth and Development

Growth promoting and retarding hormones: biosynthesis, transport, conjugation; Mode of action of these hormones and their application in plant physiology

Unit 8: Synthetic Growth Promoters

Different synthetic hormones: Salicylic acid, strigolactones etc; Roles and biological activities of various synthetic hormones; Commercial application of hormones to maximize growth and productivity

Unit 9: Morphogenesis and Reproductive Phase

Photoperiodism: Phytochromes, their structure and function; Circadian rhythms,; Blue light receptors: Cryptochrome and morphogenesis,; Vernalization and its relevance in germination.

Practicals

- Radiant energy measurements
- Separation and quantification of chlorophylls
- Separation and quantification of carotenoids
- O₂ evolution during photosynthesis
- Anatomical identification of C₃ and C₄ plants
- Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration
- Measurement of respiration rates
- Estimation of reducing sugars, starch
- Estimation of NO₃, free amino acids in the xylem exudates, quantification of soluble proteins
- Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene
- Demonstration of photoperiodic response of plants in terms of flowering

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation
- Practicals

Learning outcome

By the end of this course, the student will be able to:

- figure out the fundamental metabolic processes in plant
- describe the physiological mechanisms and metabolic events associated with regulation of plant growth

Suggested Reading

- Kirchhoff H. 2019. *Chloroplast ultrastructure in plants*, New Phytologist. Doi.org/10.1111/nph.15730
- Jafari T, Moharreri E, Amin A, Miao R, Song W and Suib S. 2016. *Photocatalytic water splitting—the untamed dream: a review of recent advances*. *Molecules*, 21(7), 900.
- Jensen E, Cle'ment R, Maberly SC, Gontero B. 2017. *Regulation of the Calvin –Benson–Bassham cycle in the enigmatic diatoms: biochemical and evolutionary variations on an original theme*. *Phil. Trans. R. Soc. B* 372: 20160401. doi.org/10.1098/rstb.2016.0401
- Raven, J. A., and Beardall, J. 2015. *The ins and outs of CO₂*. *Journal of experimental botany*, 67(1), 1-13.
- Rae, B. D., Long, B. M., Förster, B., Nguyen, N. D., Velanis, C. N., Atkinson, N. .and McCormick, A.J. 2017. *Progress and challenges of engineering a biophysical CO₂-concentrating mechanism into higher plants*. *Journal of Experimental Botany*, 68(14), 3717-3737.
- Hagemann M, Weber AP and Eisenhut M. 2016. *Photorespiration: origins and metabolic integration in interacting compartments*. *Journal of experimental botany*, 67(10), 2915.
- Kühlbrandt W. 2015. *Structure and function of mitochondrial membrane protein complexes*. *BMC biology*, 13(1), 89.
- Liesche J., and Patrick, J. 2017. *An update on phloem transport: a simple bulk flow under complex regulation*. *F1000Research*, 6.
- Jensen KH, Berg-Sørensen K, Bruus H, Holbrook NM, Liesche J, Schulz A and Bohr T. 2016. *Sap flow and sugar transport in plants*. *Reviews of modern physics*, 88(3), 035007.
- Julius BT, Leach KA, Tran TM, Mertz RA and Braun DM. 2017. *Sugar transporters in plants: new insights and discoveries*. *Plant and Cell Physiology*, 58(9), 1442-1460.

- Rao DLN. 2014. *Recent advances in biological nitrogen fixation in agricultural systems*. In *Proc Indian Natl Sci Acad* (Vol. 80, (2), pp. 359-378).
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- Mus, F., Crook, M. B., Garcia, K., Costas, A. G., Geddes, B. A., Kouri, E. D. and Udvardi, M. K. 2016. *Symbiotic nitrogen fixation and the challenges to its extension to nonlegumes*. *Appl. Environ. Microbiol.*, 82(13), 3698-3710.
- Pagare S, Bhatia M, Tripathi, N., Pagare, S., and Bansal, Y. K. 2015. *Secondary metabolites of plants and their role: Overview*. *Curr Trends Biotechnol Pharm*, 9(3), 293-304.
- Jain C, Khatana S and Vijayvergia R. 2019. *Bioactivity of secondary metabolites of various plants: a review*. *Int J Pharm Sci and Res* 10(2): 494-04. doi: 10.13040/IJPSR.0975-8232.10(2).494-04..
- Li, C., Li, J., Chong, K., Harter, K., Lee, Y., Leung, J., and Schroeder, J. 2016. *Toward a molecular understanding of plant hormone actions*. *Molecular plant*, 9(1), 1-3.
- Eckardt, N. A. 2015. *The plant cell reviews dynamic aspects of plant hormone signaling and crosstalk*.
- Jiang, K., and Asami, T. 2018. *Chemical regulators of plant hormones and their applications in basic research and agriculture*. *Bioscience, biotechnology, and biochemistry*, 82(8), 1265-1300.
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- Kumar, R., Khurana, A., and Sharma, A. K. 2014. *Role of plant hormones and their interplay in development and ripening of fleshy fruits*. *Journal of experimental botany*, 65(16), 4561-4575.
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General Text books

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- Plant Physiology* Frank Boyer Salisbury and Cleon Ross.
- Introduction to Plant Physiology* (Wie) by William G. Hopkins.

PP 504 PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC TRESSES (2+1)

Why this course?

With the changing climate, plants are being more frequently exposed to abiotic stresses like, water, salinity, temperature, nutrient, radiation, etc. limiting the productivity. This will not only affect livelihoods of individual farmers but also the food security. Concerted efforts have been made to grow crops under resource limited /stressful environmental conditions and advances in physiology, molecular biology and genetics have significantly helped in this endeavor. In recent years, our understanding of the physio-morphological, biochemical and molecular adaptation of plants to resource limited/stressful environment is phenomenal. This course will outline different abiotic stresses, their impacts on agricultural productivity, stress tolerance mechanisms, stress mitigation strategies, crop improvement approaches and traits for stress tolerance.

Aim of the course

This course aims to describe students the abiotic-stress physiology and their effects on plant growth and productivity. This will also help students gain insights into latest developments in stress physiology and stress tolerance mechanisms, approaches for crop improvement under stressful environment. The course is organized as follows:

No.	Blocks	Units
1.	Abiotic Stresses	1. Introduction to Abiotic Stresses
2.	Drought Stress	1. Moisture Stress Responses in Plants 2. Stress Perception and Molecular Responses of Plants to Drought Stress 3. Plant Adaptive Mechanisms to Drought 4. Approaches to Improve Drought Tolerance
3.	Salt, Heavy Metal, Water Logging,	1. Salt Stress Temperature and Light Stress 2. Heavy Metal Stress and Water Logging 3. Temperature and Light Stress

Theory

Block 1: Abiotic Stresses

Unit 1: Introduction to Abiotic Stresses

Abiotic stresses major constraints to realize potential yields of crop plants, yield losses. Drought prone areas in India- Frequency of occurrence of drought, Rainfed kharif, Rabi, Areas affected by salinity, heavy metals, water logging, high temperature scenario due to global warming.

Block 2: Drought Stress

Unit 1: Moisture Stress Responses in Plants

Drought-characteristic features; water potential in the soil-plant-air continuum. Physiological and biochemical processes affected by drought. Oxidative stress generation of ROS and other cytotoxic compounds, their effect on cellular process. Effect on total carbon gain- decrease in photosynthetic area and function, protein turn over and lipid characters, phenology-reproductive aspects, critical stages.

Unit 2: Stress Perception and Molecular Responses of Plants to Drought Stress

Stress perception and signal transduction leading to expression of regulatory genes, stress specific kinases, stress specific transcription factors, functional genes associated with adaptive mechanisms.

Unit 3: Plant Adaptive Mechanisms to Drought

(a) Escape and desiccation avoidance mechanism- Concept of stress escape- exploiting genetic variability in phenology, Drought avoidance mechanisms- Maintenance of cell turgor, water mining by root characters. Moisture conservation- Regulation of transpiration- traits reducing heat load, Stomatal factors guard cell metabolism, moisture conservation by waxes. Water use efficiency (WUE) and concept of water productivity- regulation of transpiration efficiency-stomatal conductance, mesophyll efficiency, relevance of WUE and Passioura's model.

(b) Desiccation tolerance- Concept of acquired tolerance Decreased turgor mediated upregulation of cellular tolerance mechanisms, Osmolytes, managing cytotoxic compounds, ROS, RCC, scavenging - enzymatic and non-enzymatic, protein turnover, stability, chaperones, membrane stability, photoprotection of chlorophylls.

Unit 4: Approaches to Improve Drought Tolerance

Development of genetic resources- donor genotypes for specific traits, Genomic resources- genes, QTL's regulating adaptive mechanisms, Conventional, transgenic and molecular breeding approaches to improve relevant adaptive traits, concept of trait introgression.

Block 3: Salt, Heavy Metal, Water Logging, Temperature and Light Stress

Unit 1: Salt Stress

Soil salinity-Effect of salt stress, ionic and osmotic effects; species variation in salt tolerance; glycophytes and halophytes, Salt tolerance mechanisms - exclusion, extrusion and compartmentalization, Signaling during salt stress – SOS pathway, Approaches to improve salt tolerance.

Unit 2: Heavy Metal Stress and Water Logging

Heavy metal toxicity in plants (eg., Al, Cd), tolerance mechanisms and approaches to improve. Plant response to water logging, role of hormones- ethylene, mechanism of tolerance and approaches to improve.

Unit 3: Temperature and Light Stress

High and low temperatures; effect on plants; adaptive mechanisms, evaporation cooling, concept of cellular tolerance, protein stability, chaperones, HSPs, HSFs, membranes. High light and high ionizing radiation- photo oxidation and photoinhibition; mechanisms of tolerance, plant adaptation to low light, concept of shade avoidance response (SAR).

Practicals

- Measurement of soil and plant water status.
- Drought stress imposition and measurement of physiological and biochemical changes in plants under stress – gas exchange and fluorescence measurements.
- Determination of water use efficiency as a drought resistant trait.
- Drought Susceptibility Index (DSI) -precise field technique to identify productive genotypes under stress.
- Approaches to quantify root characters
- Determination of stomatal parameters and canopy temperature as a reflection of transpiration and root activity.
- Determination of Salinity Tolerance Index.
- Studying acclimation response - Temperature induction response.
- Heat tolerance and membrane integrity- Sullivans heat tolerance test.
- Quantification of osmolytes – proline under stress.
- Oxidative stress imposition- Quantification of oxidative stress
- Quantification of ROS under stress.
- Estimation of ABA content in leaf and root tissues under stress.
- Determination of Sodium and Potassium in plant tissue grown under salt stress.
- Estimation of antioxidant enzymes.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation
- Practical

Learning outcome

After completion of this course students are expected to have knowledge on and insight into the physiological and molecular responses of plants to abiotic stresses. The student will develop critical insight in adaptive mechanisms of plants against various abiotic stresses.

Suggested Reading

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Lata C and Muthamilarasan M and Prasad M. 2015. *Drought Stress Responses and Signal Transduction in Plants. In elucidation of abiotic stress signaling in plants* (PP.195-225). Springer, New York, NY. DOI: 10.1007/978-1-4939-2540-7_7.

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Khan, A., Pan, X., Najeeb, U., Tan, D.K.Y., Fahad, S., Zahoor, R. and Luo, H., 2018. *Coping with drought: stress and adaptive mechanisms, and management through cultural and molecular alternatives in cotton as vital constituents for plant stress resilience and fitness*. *Biological research* 51(1), p.47.

Abobatta Waleed. 2019. *Drought adaptive mechanisms of plants -a review*. *Adv.Agr.Environ Sci.*, 2(1). 42-45. DOI: 10.30881/aaeoa.00021.

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Why this Course?

Many plant growth and developmental processes are regulated by phytohormones. It is important to understand the hormone biosynthesis, structure, function, signal transduction and their practical application. It is also important to provide basic knowledge on manipulating growth and developmental processes using plant hormones.

Aim of the course

It provides knowledge on the fundamentals of hormone biosynthesis, homeostasis, transport and signaling and the role in regulating basic physiological processes governing developmental events in plants. The role of classical hormones on developmental processes from germination, shoot and root apical meristem differentiation, flowering, seed maturation and senescence. The aim of this course is to appraise the students about structure and function of plant growth regulators.

The course is organized as follows:

No.	Blocks	Units
1.	Plant Growth and Development:	1. Introduction to Plant Hormones Hormonal Regulation 2. Plant Hormones - Discovery and Metabolism 3. Physiological Role of Hormones in Plant Growth and Development 4. Endogenous Growth Substances other than Hormones 5. Hormone Signaling 6. Key Genes Regulating Hormone Levels and Functions 7. Crosstalk of Hormones in Regulation of Plant Growth and Development Processes 8. Practical Utility of Growth Regulators in Agriculture and Horticulture

Theory**Block 1: Plant Growth and Development: Hormonal Regulation****Unit 1: Introduction to Plant Hormones**

Growth, differentiation and development regulated by plant growth substances, Definition and classification of growth regulating substances: Classical hormones, Definition and classification of growth regulating substances: Endogenous growth substances other than hormones, Synthetic chemicals.

Unit 2: Plant Hormones – Discovery and Metabolism

Discovery, biosynthetic pathways and metabolism of Auxin, Discovery, biosynthetic pathways and metabolism of Gibberellins, Discovery, biosynthetic pathways and metabolism of Cytokinins, Discovery, biosynthetic pathways and metabolism of Absciscic acid, Discovery, biosynthetic pathways and metabolism of Ethylene, Discovery, biosynthetic pathways and metabolism of Brassinosteroids, Discovery, biosynthetic pathways and metabolism of Strigolactones.

Unit 3: Physiological Role of Hormones in Plant Growth and Development

Physiological functions of Auxin and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Gibberellins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Cytokinins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Absciscic acid and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Ethylene and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Brassinosteroids and Strigolactones and use of mutants and transgenic plants in elucidating the physiological functions, Discovery, biosynthetic pathways metabolism and physiological roles of Salicylic acid and Peptide hormones.

Unit 4: Endogenous Growth Substances other than Hormones

Discovery, biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins, Discovery, biosynthetic pathways metabolism and physiological roles of Jasmonates and Tricentanol, Discovery, biosynthetic pathways metabolism and physiological roles of systemins Concept of death hormone, Recent developments in elucidating responses of Salicylic acid, Peptide hormones and Polyamines at physiological and molecular level, Recent developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricentanol at physiological and molecular level.

Unit 5: Hormone Signaling

Hormone signal perception, transduction - Receptors, components and mechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid), Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones), Advances in elucidating the structure and function of receptors and signaling components of important hormones.

Unit 6: Key Genes Regulating Hormone Levels and Functions

Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies.

Unit 7: Crosstalk of Hormones in Regulation of Plant Growth and Development Processes

Crosstalk of Hormones in Regulation of Plant Growth and Development Processes: Floral transition, reproductive development, Shoot and root apical meristem development

Unit 8: Practical Utility of Growth Regulators in Agriculture and Horticulture

Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings, Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits, Practical Utility of Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop.

Practicals

- Extraction of Auxins from plant tissue
- Separation and detection of Auxins by GC / GC-MS / HPLC / Immunological technique
- Bioassay of auxin- effect on rooting of cuttings
- Extraction of abscisic acid (ABA) from plant tissue
- Separation and detection of ABA by HPLC/Immunological technique
- ABA bioassays- effect on stomatal movement
- Preparation of samples for ethylene estimation in plant tissue
- Estimation of ethylene in plant tissues using gas chromatography
- Ethylene bioassays, estimation using physico-chemical techniques- effect on breaking dormancy in sunflower and groundnut
- Extraction of Gibberellins from plant tissue- GC / GC-MS / HPLC
- Separation and detection of GA by GC / GC-MS / HPLC/Immunological technique
- GA bioassays- effect on germination of dormant seeds
- Cytokinin- extraction from plant tissue
- Separation and detection of cytokinin by GC / GC-MS / HPLC
- Cytokinin bioassays- effect on apical dominance and senescence / stay green

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation
- Practicals

Learning outcome

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

- acquire basic knowledge about plant hormones and plant growth regulators.
- understand the physiological roles and mechanisms of actions of plant hormone.
- obtain practical knowledge about application of plant growth regulators in agricultural and horticulture.

Suggested Reading

Davies P.J. 2004, *Plant Hormones: Biosynthesis, Signal Transduction and Action*, 2nd Edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Hedden, P. and Thomas, S.J. 2006. *Plant Hormone Signalling*, Blackwell Publishing Ltd., Oxford, UK.

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Buchanan B B, Gruissem W and Jones R L. *Biochemistry and Molecular biology of Plants*, 2nd Edition

Lincoln Taiz and Eduardo Zeiger. *Plant Physiology and Development*, 6th Edition.

Teaching Tools in Plant Biology, The American Society of Plant Biologists

The Arabidopsis Book (<http://www.arabidopsisbook.org/>)

Why this Course?

Improving physiological processes forms the basis to enhance the productivity or to improve a specific growth processes. Several interventions based on principals of physiological processes provide options to enhance crop productivity. Basic insight on photoperiodic response is crucial for determining planting dates. Understanding the mechanisms of rooting for vegetative propagation has lead in developing rooting hormones etc., In view of this, a comprehensive exposure on growth and development of horticulture crops and providing insights on major production constraints and physiological approaches to overcome is highly essential.

Aim of the Course

This course should provide a broad exposure on the physiological aspects of horticulture crops. The objective is to impart comprehensive information on physiological processes and physiological basis of growth, development and productivity of horticultural crop plants. To describe basic and applied physiology behind the production and productivity of horticultural crops and their pre and postharvest management, ideal storage conditions, quality retention, processing and value addition. Broad categories of crops that can be selected for this course are as follows.

1. Fruit crops: Mango, Grapes, Apple, Banana, Citrus etc.
2. Vegetable crops: Tomato, Onion, Brinjal, Cauliflower, Okra etc.
3. Tuberous crops: Potato, Cassava, Sweet potato, Yam etc.
4. Plantation crops: Coconut, Oil palm, Cashew, Tea, Coffee, Rubber, Areca nut, Cocoa etc.
5. Floriculture crops: Rose, Marigold, Carnation, Chrysanthemum, Gladiolus, Orchids, Tuberose etc.
6. Other groups: Medicinal crops, Aromatic crops, Spices crops.

The course is organized as follows:

No.	Blocks	Units
1.	Physiology of Horticultural Crops	1. Introduction 2. Crop growth and Development 3. Reproductive Growth 4. Pre and Post-harvest Physiology 5. Plant Nutrition and Abiotic Stress Responses 6. Specific Aspects and Unique Crop Features

Learning outcome

After completion of this course, students will accrue comprehensive knowledge on various physiological processes of variety of horticultural crops.

Theory**Block 1:** Physiology of Horticultural Crops

Unit 1: Introduction: Origin, distribution and adaptability of crops to different agro-climatic conditions

Unit 2: Crop growth and Development: Internal factors (hormone, etc.) influencing various physiological processes linked to vegetative growth or growth of specific organ, correlative and allometric growth External factors (water, nutrition, temperature, etc.) influencing various physiological processes linked to vegetative growth or growth of specific organ, correlative and allometric growth, Propagation methods, grafting, cutting, budding, air layering. Physiology of pruning, dwarfing, branch bending, canopy management etc., Physiological and biochemical aspects of scion and root stock interaction and compatibility.

Unit 3: Reproductive Growth: Physiology of flowering, photo- and thermo-periodism and response to vernalization, Factors influencing reproductive growth, fruit and seed set/retention, physiology of flower sex ratio, Physiological processes governing source-sink relationship and productivity.

Unit 4: Pre and Post Harvest Physiology: Preharvest factors influencing postharvest physiology, physiological

and molecular mechanisms of ripening, Physiological and molecular mechanisms of senescence, Hormonal and chemical control of postharvest deterioration of fruits/vegetable/flowers. Regulation of ripening at physiological and molecular levels, Regulation of senescence at physiological and molecular levels, Approaches to improve shelf life and storability. Approaches to improve postharvest management, Approaches to improve processing and value addition.

Unit 5: Plant Nutrition and Abiotic Stress Responses: Nutrient acquisition and requirement, plant phenology and nutrient requirement; Role of rootstocks in nutrient acquisition and in abiotic stress tolerance, Adaptive mechanisms and approaches to improve performances under drought and high temperature, Adaptive mechanisms and approaches to improve performances under frost, chilling and nutrient deficient conditions, Root physiology in abiotic stress tolerance.

Unit 6: Specific Aspects and Unique Crop Features: Specific aspects Polyhouse cultivation, Hormones/PGRs for improving crop performance, Major and micronutrients for improving crop performance, Light interception, shade regulation, dwarfing root stocks, Chilling requirement for flowering, photoperiodic response, pollen viability, stigma receptivity, Flower (blossom) and fruit drop. Unique crop features
Maturity and maturity indices, Source-sink relations, Vegetative propagation, Physiology of tuberization and rhizome initiation and formation, Virus free planting material, Bulbs/tubers dormancy, bud break, Physiological disorders, Storage, Packaging, Quality.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

Suggested Reading

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Why this Course?

Besides crop improvement, the approach to regulate physiological processes for improving crop production made very good leads in recent years. The focus is to employ the basic knowledge of several physiological processes to manipulate the plant growth and specific processes like ripening, flowering to achieve higher economic yields. This dynamic course will address many of these technologies that are being developed for crop production based on principles of plant physiological processes. Training the students in this student ready course will provide the required practical knowledge which will be of immense relevance to contribute private agricultural sectors and for agri-based industries.

Aim of the Course

A comprehensive information needs to be provided in this course like light regulation in polyhouse cultivation, photoperiod responses by red/far red light for synchronizing flowering, techniques for soil less culture like aeroponics, pollen biology and hybrid production, chemical regulation of plant growth processes like flower initiation, flower sex, flower drop, fruit maturity, ripening and shelf-life, etc.

The course is organized as follows:

No	Blocks	Units
1.	Propagation - Crop Establishment	1. Seed as a Propogule 2. Vegetative Propogule
2.	Regulation of Plant Growth	1. Regulation of Plant Growth and Flowering Processes 2. Fruit Ripening and its Regulation 3. Concept of Senescence and its Retardation
3.	Protective Cultivation–Stress	1. Protective Cultivation Interventions to Alter Mitigation
	Physiological Processes and Growth	2. Drought Mitigation Options and Approaches
	Hormones	3. Specific Plant Processes Regulated by Chemicals and Growth

Theory**Block 1:** Propagation - Crop Establishment**Unit 1:** Seed as a Propogule

Concept of improving seed characteristics for crop establishment. Mechanisms of regulating seed dormancy, precocious germination, ways to control pre-harvest sprouting in crop plants. Seed viability and its regulation, factors to minimize loss of viability and improve seedling vigour. Concept of seed priming, techniques of priming, seed priming to induce tolerance to stresses. Role of media, nutrition and PGPR's on seedling vigour and subsequent crop establishment.

Unit 2: Vegetative Propogule

Chemical and hormonal regulation of vegetative propagation. Regulation of rooting, bud sprouting, Bulb/tuber dormancy. Chemical regulation of graft union. Concept of in vitro micropropagation.

Block 2: Regulation of Plant Growth Processes

Unit 1: Regulation of Plant Growth and Flowering Chemical and hormonal regulation of plant architecture, tillering, branching, bud breaking, Regulation of flowering by photo and thermoperiod, nutrients, chemicals and hormones, concept of speed breeding, Flowering synchrony in hybrid seed production, Sex ratio alteration, flower and fruit thinning, Pollen viability in relation to environment, harvesting, storage and transportation, Prevention of abscission, flower and fruit drop, seed and fruit growth regulation- role of hormones.

Unit 2: Fruit Ripening and its Regulation

Approaches to improve shelf life –storage environment, water loss, respiration, Modified atmosphere, gaseous environment for storage, storage disorders, chilling injury.

Unit 3: Concept of Senescence and its Retardation

Physiology of senescence and options to regulate, Chemical regulation of senescence, maintenance of chlorophyll during storage, role of hormones/micronutrients in reducing senescence, Concept of stay green, advantages and

limitations. Relevance of stay green traits in plant breeding for crop improvement.

Block 3: Protective Cultivation–Stress Mitigation

Unit 1: Protective Cultivation Interventions to Alter Physiological Processes and Growth Spectral characteristics of light in polyhouse, light regulation to optimize plant photosynthetic and photomorphogenic processes and plant growth, LED sources of monochromatic light to regulate growth, etiolating and flowering, High temperature induced thermomorphogenic processes, Artificial growing media, soilless cultures, aeroponics, fogponics, Concept of CO₂ fertilization. Effect of humidity on leaf expansion and growth.

Unit 2: Drought Mitigation Options and Approaches

Moisture conservation options at soil and plant level, Concept of increasing water holding capacity, role of Hydrogels – water and mineral nutrients release pattern. Approaches to improve transpiration over evapo-transpiration, stomatal and nonstomatal regulation of water loss, antitranspirants, Osmoprotectants, ROS scavengers, plant nutrients, Root stocks in improving tolerance, Chemical regulation of flower drop due to temperature, Chemicals to improve pollen viability during abiotic stress.

Unit 3: Specific Plant Processes Regulated by Chemicals and Growth Hormones

Rooting of cuttings, Wine brewing industry, Promotion of gynoeceous flower, Hybrid rice production, Induction of flowering in pine apple, cucurbits, Delaying of senescence and ripening, Production of dwarf plant for ornamental purpose, Reduction in flower and fruit drop, Increase in berry size in grapes.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

Suggested Reading

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PP 602 SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES

Why this course?

Biosignaling is emerging as an important field in plant biology. Thorough understanding of signal perception, activation and cellular changes associated is needed for manipulation of specific traits or events in plants. The M.Sc. PhD scholar working on plant biology and related field must be exposed to this new emerging area. Plant response to external and internal factors is mainly through signal perception and amplification leading to gene expression which brings in altered metabolism regulating physiological and biochemical processes and finally plant processes and growth. The course provides insights on the diverse receptors, ligand receptor interaction and the role of secondary messengers in signal amplification leading to gene expression and finally regulating plant growth.

Aim of the course

Objective of this course is to provide comprehensive exposure on different signaling events and associated cellular changes in plants. The course will include lectures on the signalling mechanisms employed by plants to perceive and transduce environmental signals.

The course is organized as follows:

No	Blocks	Units
1	Signal Perceptions and Transduction:	1. Concept of Receptor and Ligands Regulation of Physiological Processes 2. Receptors – Signal Perception and Transfer 3. Hormone Signaling 4. Light Signaling 5. Abiotic Stress Signaling and Nutrient Signalling 6. Signaling Cascade during Developmental Events 7. Signal Perception and Transduction in Plant Defense Responses

Theory

Block 1: Signal Perceptions and Transduction: Regulation of Physiological Processes

Unit 1: Concept of Receptor and Ligands

Signal, signal types, long (diffusible) and short (contact) range signaling and components of signaling. Types of receptors, nature of ligands, downstream components like primary, secondary signaling components.

Unit 2: Receptors – Signal Perception and Transfer

Cell surface trans-membrane receptors- GPCRs, Receptor Tyrosine Kinases (RTKs), Receptors Serine Threonine kinases (RSTKs), Receptor-Like Kinases (RLKs), receptor two component systems. Signal transfer phospho-relay and generation of secondary signaling components and activation of TFs or enzymes. Downstream components- G-proteins, second messengers-Cyclic AMP, Adenylate cyclase cascade, cyclic GMP, calcium-calmodulin-kinases; effector molecules (transcription factor).

Unit 3: Hormone Signaling

Hormone binding receptors-Transduction process. Effector molecules and gene expression. Specific signaling pathways of Auxins, Cytokinin, Gibberellins, Ethylene, ABA, Brassinosteroids, Salicylic Acid, Strigolactone, polyamines, Jasmonic acid, etc. which leads to formative effects. Cross talk in the signaling of different hormones-significance of studies with hormone action mutants.

Unit 4: Light Signaling

Perception of light-pigments involved- activation of phytochrome/cryptochrome (study of mutants). Light signal transduction. Multiple signaling cascades-identification of signaling components through mutant analysis-changes in gene expression.

Unit 5: Abiotic Stress Signaling and Nutrient Signalling

Sensing of environmental factors (Temperature-Osmotic-Ionic stress), Activation of specific molecules and

secondary messengers, activation of downstream components-leading to stress gene expression, Case studies with different abiotic stresses, Retrograde signaling, Nitrogen fixation, nitrogen and phosphorus uptake, nutrient translocation.

Unit 6: Signaling Cascade during Developmental Events

Leaf senescence/fruit development and ripening, Tuberization, Sugar signaling. Signaling during seed germination.

Unit 7: Signal Perception and Transduction in Plant Defense Responses

General mechanisms to pathogen response, Role of salicylic acid and active oxygen species, Cross Talk Signaling- Stress matrix under field conditions, cross talk between abiotic-abiotic stress, biotic-abiotic stress signaling networks.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

Learning outcome

By the end of this course, the student will be able to:

1. comprehendvarioussignaling events and associated physiological changes in plants.
2. understand the diverse roles of receptors, ligand receptor interaction and the role of secondary messengers in signal amplification leading to gene expression.

Suggested Reading

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longiflorum ASR during pollen maturation and in transgenic Arabidopsis. *International Review of Cell and Molecular Biology* (301: pp. 37-94). Academic Press.

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Sparks, E., Wachsman, G. and Benfey, P.N., 2013. Spatiotemporal signalling in plant development. *Nature Reviews Genetics*. 14(9), p.631.

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2017. World Scientific Publishing Europe Ltd ISBN-13: 9781786340443

Annual Plant Reviews: Intracellular Signaling in Plants Hedden P, Napier R, Yang Z (Ed) 2008, Wiley-Blackwell
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Why this Course?

Present Indian agriculture encounters tremendous challenges due to rapid climate change. Climate change exerts remarkable negative impact on food, nutritional and ecological security. It significantly affects the plant physiological processes, hence yield is severely affected. Therefore students of plant physiology need to equip themselves with knowledge and skill sets required to navigate the climate change scenario and its impact on crops physiological processes. Hence, this course is designed .

Aim of the Course

The course is designed to provide basic knowledge on the subjects of crop responses to climate change. The aim of this course is to address both long-term and short term effects of climate change on crops, natural vegetations and ecosystems.

The course is organized as follows:

No.	Blocks	Units
1.	Climate Change: Crop Response and Mitigation	1. Fundamentals of Climate Change 2. Manifestations of Climate Change 3. Major GHGs (CO ₂ , Methane, NO ₂ etc.), their Production Rates, Monitoring and their Influence on Climate Change 4. Agricultural Practices on GHG Production 5. Direct and Indirect Effects of Climate Change on Plant Processes 6. Climate Change Scenario and Impact on Crops 7. Ozone Depletion leading to Increased Ionizing Radiations and its Implications on Crop Growth 8. Long-term and Short-term Projections of Climate Change: Effects on Natural Vegetation and Ecosystems 9. Technologies for Climate Change Mitigation in Agriculture 10. Climate-resilient Agriculture 11. Climate Change: Technologies for Crop Response Studies 12. Politics of Climate Change Negotiations

Theory**Block 1:** Climate Change: Crop Response and Mitigation**Unit 1:** Fundamentals of Climate Change

Definition of climate change, history and evidences of climate change and its implications. Natural and anthropogenic climate change. Sources of Greenhouse Gas (GHG) emission, Global Warming Potential of GHGs, accumulation of GHGs in the atmosphere and science behind climate change, industrial revolution and GHG build-up in the atmosphere, Energy-Emission-Economy Interactions, carbon intensity of economy, carbon equity/justice.

Unit 2: Manifestations of Climate Change

Impact on monsoons, occurrence of extreme weather events, hydrological cycle and water availability, effect on crop growing period in tropics, subtropics and temperate regions, shifts in distribution of flora and fauna, effects on biodiversity and migration of tropical plant species to higher latitudes and altitudes.

Unit 3: Major GHGs (CO₂, Methane, NO₂, etc.), their Production Rates,

Monitoring and their Influence on Climate Change GHGs: An Overview, - role of CO₂, methane and major uncertainties. Mechanism of their production and emission from various, source and sinks of GHGs; and contribution of GHGs to global warming. Techniques used in monitoring GHGs.

Unit 4: Agricultural Practices on GHG Production

Carbon footprint analysis of agriculture and various agricultural practices contribute to climate change. Impacts of natural factors and farming practices on greenhouse gas emissions. Sources of agricultural GHG emission-

Agricultural Soil Management, enteric fermentation, manure management, other sources. Opportunities to reduce GHG emission from Agriculture.

Unit 5: Direct and Indirect Effects of Climate Change on Plant Processes

Problems and Prospects of Crops with changing temperature: Growth and Development of Crop plants, Thermomorphogenesis, phenology, Physiological processes such as photosynthesis, Net carbon assimilation, C3 and C4 plants adaptation, Respiration, Nutrient acquisition and metabolisms, Plant water relations and Heat shock proteins, Grain/seed development: Grain Quality parameters and yield.

Unit 6: Climate Change Scenario and Impact on Crops

Different scenarios for temperature, rainfall in different agro-climatic zones of India and their impact on crop growth and productivity. Major climate change (temperature, CO₂, and rainfall) impact quantification using field or controlled environment experiments, meta-analysis and simulation models. Some examples of crop simulation models calibration and their application in short-term and long-term predictions.

Unit 7: Ozone Depletion leading to Increased Ionizing Radiations and its Implications on Crop Growth

Role of CFCs in ozone depletion, penetration of ionizing UV radiations and its implications on crop growth.

Unit 8: Long-term and Short-term Projections of Climate Change: Effects on Natural Vegetation and Ecosystems

Response of natural ecosystems to increasing atmospheric CO₂ concentration and climate warming, effect of climate change on quality of feed i.e. leaf and stored grains/seeds, its implications on pollinators and pests

Unit 9: Technologies for Climate Change Mitigation in Agriculture Agricultural biotechnology to produce crop varieties with enhanced carbon uptake. Nutrient management: Management of nitrogenous fertilizers.

Tillage/residue management: 1. Conservation tillage CO₂ mitigation technology; 2. Biochar: A potential technique for carbon sequestration. Methane mitigation using reduced tillage technology, change in methanogenic bacterial activity using electron acceptors. Carbon sequestration potential, concept and measurement.

Unit 10: Climate-resilient Agriculture

Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of “Genome wide mutants” to identify genes/processes for improved adaptation to changing environments.

Unit 11: Climate Change: Technologies for Crop response studies

Temperature Gradient Chambers, Temperature Gradient Greenhouses, Soil plant atmosphere research system (SPAR), Infra-red warming Technology, Free Air temperature enrichment technology, Soil Warming system etc.

Unit 12: Politics of Climate Change Negotiations

IPCC, Major International conventions/treaties, Kyoto Protocol, Paris Agreement, Global initiatives on Carbon sequestration, carbon trading.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

Learning outcome

After completion this course, students will be able to obtain in depth and basis knowledge on crop responses to climate change.

Suggested Reading

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India's Second National Communication to UNFCCC

INCCA Report, MoEF and CC

MoEF and CC website

Why this course?

Yield level reached plateau in many crops improving yield potential and crop growth rate forms the basis for further improvement in productivity. Photosynthesis and the establishing sink capacity are crucial processes to achieve this goal. Very good progress has been made in deciphering the molecular mechanisms to regulate several photosynthetic processes at cellular and canopy level. Similar insights now exist regarding establishing sink size (capacity). In the last five years, phenomenal conceptual approaches have been developed to understand the basic physiological and molecular mechanisms to enhance the source through photosynthetic processes. Besides, scientific insights in recent years provided leads in improving sink ie., yield associated traits. Yield plateau can be broken only by enhancing yield potential by structured improvement in source capacity and sink size.

Aim of the course

The course addresses the recent development in photosynthetic processes that can be exploited to improve yield potential. Besides, other major emphasis is to provide exposure on recent developments in regulating the sink characters ie., yield attributes at molecular level to achieve higher potential yields.

The course is organized as follows:

No.	Blocks	Units
1.	Source Size and Function- Basic	1. Source Establishment Concepts, Physiological and 2. Source Function- Photochemical Reactions Molecular Mechanisms, Genomic 3. Source Function- CO ₂ Diffusion and RESOURCES to Regulate Source Concentration Characters 4. Source Function- Metabolic Engineering of CO ₂ Fixation 5. Case Studies to Improve Source Capacity
2.	Improving Sink Size and Capacity	1. Sink Establishment 2. Increase the Sink Size by Enhancing the Relevant Constituent Traits 3. Genetic Genomic RESOURCES, Genes/QTLs, Genetic RESOURCES to Improve Sink Traits– Case Studies 4. Source to Support the Sink Capacity

Theory

Block 1: Source Size and Function–Basic Concepts, Physiological and Molecular Mechanisms, Genomic Resources to Regulate Source Characters

Unit 1: Source Establishment: Maximize energy capture by improved light interception, light distribution and its utilization efficiency, concepts of shade avoidance response (SAR) and option to increase, Increase canopy size by vertical expansion – concept of increasing optimum LAI levels, Concepts of semi-tall varieties with resistance to lodging; traits associated with lodging resistance, Sustain net carbon gain with age – the relevance of stay green character, photon capture and achieve high CO₂ reduction to photon ratio under low light, Options for increasing canopy photosynthesis, Relevance of maintaining cell turgor and nutrient status.

Unit 2: Source Function- Photochemical Reactions Maximize conversion efficiency of intercepted radiation by improving net carbon gain - Emerging solutions to increase carbon fixation rate, Improve efficiency of photochemical reaction by - Engineering the pigments to expand PAR spectrum into IR range; reduce antenna size, optimize energy dissipation mechanisms; optimize components of ETC and downstream acceptors; accelerate adaptation for shifting light intensities.

Unit 3: Source Function- CO₂ Diffusion and Concentration Enhance stomatal conductance (gs) and esophyll conductance (gm) – guard cell metabolism; concepts of leaf mesophyll tissue thickness (SLW), Concepts of VPD responses of gs to enhance duration of photosynthesis during the day, Bicarbonate transports and aquaporins; achieve higher CCM - Engineering C₄ cycle, CAM, cyanobacteria, carboxysomes, algal pyrenoids.

Unit 4: Source Function- Metabolic Engineering of CO₂ Fixation RuBisCO carbon fixation activity - Increase

and optimize kinetics of RuBisCO with enhanced specificity to CO₂, Engineer RuBisCO to minimize feedback regulation by metabolite inhibitors, Increased activation state by improving stability and function of RuBisCOactivase; optimize RuBp regeneration – modulate specific enzyme levels. New concepts on photorespiratory synthetic bypass.

Unit 5: Case Studies to Improve Source Capacity Genetic and genomic resources, genes/QTLs associated with specific yield potential traits and/or photosynthetic mechanisms, Genetic resources to improve source traits case studies.

Block 2: Improving Sink Size and Capacity

Unit 1: Sink Establishment: Optimise duration of phenological stages related to sink establishment, genetic and environmental factors, GDD and phenology.

Unit 2: Increase the Sink Size by Enhancing the Relevant Constituent Traits Role of hormones in regulating molecular mechanisms of yield structure development, Genomic and genetic resources developed for regulation/improvement of such traits. – Sink Size: Tillering associated traits, branching patterns/fruitlet points, spikelet number, pod number, fruit number. – Sink development: Basic concepts and molecular mechanisms associated with pollination, fertilization, ovary development in determining the spikelet fertility/sterility components and strategies for engineering seed/fruit size in crop plants.

Unit 3: Genetic and Genomic Resources, Genes/ QTLs, Genetic Resources to Improve Sink Traits- Case Studies. Progress and status in developing genomic and genetic resources of validated genes/ QTLs to improve sink traits- Specific case studies.

Unit 4: Source to Support the Sink Capacity Canopy architecture to support sink requirements in cereals: plant height, tillering, leaf area, shading or senescence of lower canopy leaves, canopy photosynthesis, Canopy architecture to support sink requirements in Pulses: Leaf senescence, abscission, mobilization of N and other nutrients, Symbiotic N fixation to support sink size and capacity in pulses.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

Learning outcome

By the end of this course, the student will be able to:

1. comprehend the current development in photosynthetic research
2. know how to employ the theoretical concept of photosynthetic research in yield improvement programme
3. understand the mechanisms of source and sink establishment

Suggested Reading

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E. POST HARVEST MANAGEMENT

M.Sc. Syllabus

PHM 501 POST HARVEST MANAGEMENT OF HORTICULTURAL PRODUCE (2+1)

WHY THIS COURSE?

Fruits and vegetables are perishable crops that suffer great losses both in quantity and quality after harvest. These produce require integrated approach to arrest their spoilage and overcome the present day challenges that assimilates millions of tons annually. Lack of postharvest awareness and absence of sufficient and functioning equipment in the postharvest chain result in serious postharvest losses in developing countries. Clear and comprehensive understanding of postharvest deteriorative factors is necessary to overcome these challenges. Pre and postharvest management such as good cultural practices, use of improved varieties, good handling practices pre and postharvest, temperature and relative humidity management, storage atmosphere management, use of permitted chemicals, design of appropriate packaging materials and storage structures are some of the control measures use in reducing postharvest losses. Hence this customized course

AIM OF THIS COURSE:

To impart comprehensive knowledge on management of horticultural produce thus extending the post-harvest life of the produce by various treatments.

The course is organized as follows

No	Blocks	Units
1	Postharvest management of horticultural produce	1. Importance and scope
		2. Regulation of ripening
		3. Treatments for extending shelf life
		4. Handling system and marketing of horticultural crops

LEARNING OUTCOMES:

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

Regulation of ripening by use of chemicals and growth regulators

Pre and Postharvest treatments for extending storage life/vase life

Standards and specifications for fresh produce

THEORY:

Block 1: Postharvest Management of Horticultural Produce

UNIT-I:

History, Importance and scope of Postharvest technology of horticultural produce. Nature and structure of horticultural produce. Pre and Postharvest losses and their causes.

UNIT-II:

Climacteric and non-climacteric fruits. Regulation of ripening by use of chemicals and growth regulators. Control of sprouting/rooting and discoloration in vegetables.

UNIT-III:

Maturity indices for harvest. Harvesting and harvesting tools. Curing in roots and tubers. Prepackage Operation: Precooling, washing, sorting, grading of horticultural perishables for local markets and export. Postharvest handling of spices, plantation crops, medicinal and aromatic plants. Equipments for washing, sizing, grading.

UNIT-IV:

Pre and Postharvest treatments for extending storage life/vase life. VHT, irradiation treatment, skin coating, degreening, etc. Pre-packaging, Packaging techniques for local market and export. Standards and specifications for fresh produce.

UNIT-V:

Postharvest handling system for horticulture crops of regional importance. Principles of transport, modes of transportation, types of vehicles and transit requirements for different horticultural produce. Marketing: Factors influencing marketing of perishable crops, marketing systems and organizations.

PRACTICALS:

Study of maturity indices for harvest of fruits, vegetables, spices and plantation crops.

Protective skin coating with wax emulsion and pre and Postharvest treatment with fungicides, chemicals and growth regulators to extend the shelf life of fruits and vegetables.

Prepackaging of perishables

Extension of vase life of cut flowers by use of chemicals and growth regulators.

Control of sprouting of potato and onion by using growth regulators.

Study of modern harvesting, sorting and grading equipments.

Study of effect of pre-cooling on shelf-life and quality of fresh fruits, vegetables and flowers.

Visit to packaging centers.

Visit to local markets, cooperative organizations, super markets dealing with marketing of Perishables.

TEACHING METHODS / ACTIVITIES

Lectures

Assignments (Reading/Writing)

Exposure visits

Student presentation

Group Work /seminars

RESOURCES:

Thompson A. K. (Ed.) (2014) Fruit and Vegetables: Harvesting, Handling and Storage (Vol. 1 & 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.

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

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Websites:

Horticulture Post-harvest management CSIR-NISTADS

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Post harvest technology- MANAGE <http://www.manage.gov.in/ftf-itt/prgReports/iuhr.pdf> Role of post-harvest management <http://www.fao.org/3/y5431e/y5431e02.htm>

WHY THIS COURSE?

Immediately after harvesting, vegetables and fruits are subjected to the active processes of degradation. Numerous physiological and biochemical processes continuously change the original composition of the crop until which decrease the shelf life of the produce. Postharvest physiology is the scientific study of the physiology of living plant tissues after picking. It is very much necessary to learn about it as has direct applications to postharvest handling in establishing the storage and transport conditions that prolong shelf life. Hence this customized course.

AIM OF THIS COURSE

To impart comprehensive knowledge on physiology of horticultural produce after harvest and to understand different physiological processes like respiration ripening

The course is organized as follows:

S. No.	Blocks	Units
	Biochemistry of perishable	1. Structure and composition of horticultural produce
		2. Biochemical Changes after harvest
	Postharvest physiology of perishables	1. Maturity, Ripening and respiration
		2. Respiratory climacteric and transpiration
		3. Factors affecting shelf-life

LEARNING OUTCOMES

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

THEORY:

Block 1: Biochemistry of Perishables

UNIT I: Introduction, biochemical structure and composition of fruits, vegetables and ornamentals.

UNIT-II: Biochemical changes during development and ripening. Structural Deterioration of the Produce-cell wall degradation, change in membrane lipid: Biosynthesis of ethylene and its regulation. Ethylene action and ripening processes, its perception-action and regulation

Block 2: Postharvest physiology of perishables

UNIT-I: Determining Maturity and maturity indices. Ripening processes: events of ripening and factors affecting them

UNIT-II: Physiology of preharvest and postharvest; factors affecting shelf-life and quality of fruits, vegetables and ornamentals.

UNIT-III: Respiration: respiratory climacteric, its significance. Transpiration and water stress during postharvest. Postharvest oxidative stress: active oxygen species, AOS generation, physiological effects on horticultural commodity, control of oxidative injury.

PRACTICALS:

Determination of physical parameters like specific gravity ,fruit firmness etc.,

Determination of physiological loss in weight.

Determination of chemical constituents like sugar, starch, pigments, Vitamin C, acidity during maturation and ripening in fruits/vegetables.

Estimation of ethylene evolved from ripening fruits.

Delay/Hastening of ripening by ethylene treatments.

Determination of firmness, TSS, moisture, Titratable acid, sugar, protein, starch, fats, chlorophyll, carotene, anthocyanin, phenols and tannins.

Measurement of respiration and ethylene evaluation.

TEACHING METHODS / ACTIVITIES

Lectures

Assignments (Reading/Writing)

Exposure visits

Student presentations

Group Work

RESOURCES:

Wills R. B. H. and Golding, J. (2017)Advances in Postharvest Fruit and Vegetable Technology, CRC Press, ISBN 9781138894051.

Sunil Pareek (Ed.) (2016) Postharvest Ripening Physiology of Crops,CRC Press, ISBN 9781498703802.

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

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.

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

D. Mark Hodges (2003) Postharvest Oxidative Stress in Horticultural Crops, 1st Edition, ISBN 9781560229636

Thompson, A.K. 1995 Post harvest Technology of fruits and vegetables. Blackwell Sciences

Chadha K.L. and Pal R.K. (2015) Managing postharvest quality and losses in Horticultural crops. Vol-1: General Issues, 1-231p Astral International (P) Ltd., New Delhi

Chadha K.L. and Pal R.K. (2015) Managing postharvest quality and losses in horticultural crops. Vol-2: Fruit Crops, 253-561p Astral International (P) Ltd., New Delhi

Chadha K.L. and Pal R.K. (2015) Managing postharvest quality and losses in horticultural crops. Vol-3: Vegetables, Flowers and Plantation Crops, 581-727p Astral International (P) Ltd., New Delhi

WHY THIS COURSE?

Being a potential source of minerals, vitamins and proteins and carbohydrates, horticultural commodities play an important role in the health and nutritional security of the people. Proper packaging and storage will utilize market surplus during glut season and thus give boost to the food industry. Horticultural produce is highly perishable particularly under tropical conditions of India. The spoilage of these commodities can be reduced to a large extent by this storage technology. Hence this customized course

AIM OF THIS 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	1. Importance of storage
		2. Different methods of storage
		3. Modified methods of storage
2	Packaging	1. Importance of packaging and packaging methods
		2. New technologies in packaging

LEARNING OUTCOMES

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

Importance of storage of horticultural produce

Different methods of storage

Importance of packaging for fresh horticultural produce

Different methods of packaging

THEORY:**Block 1: Storage Systems**

UNIT-I: Importance of storage of horticultural produce, present status and future scope. Principles and methods of storage – field storage structures and designs for bulk storage of horticultural produce onion and potato etc. Evaporative cool chambers. Physiological changes during storage.

UNIT-II: Refrigerated storage - principles of refrigeration, types of refrigerants, refrigeration equipments. Cold storage rooms - Calculation of refrigeration load. Storage requirements of different fruits, vegetables, flowers. Storage disorder symptoms and control.

UNIT-III: Controlled or modified atmosphere (CA/MA) storage - principles, uses, structures and equipments, methods and requirements. Effect of CA storage on the physiology of stored produce. Hypobaric storage-principle, uses, and requirements. Storage disorders.

Block 2: Packaging

UNIT-I: Importance of packaging of fresh and processed horticultural produce, present status and future scope. Gaps in packaging concepts. Packaging requirements of fresh horticultural produce. Packaging patterns and methods. Food packaging systems: Different forms of packaging such as rigid, semi-rigid, flexible forms. Traditional, improved and specialized packages. Paper based packages: corrugated fibre board boxes - raw material and types of boxes. Flexible packaging materials - types and their properties. Consumer and intermediate flexible bulk containers. Testing of flexible packaging material. Barrier properties of packaging materials.

UNIT-2: New technology in packaging - stretch wrapping system, vacuum packaging, gas packaging, controlled atmosphere (active and intelligent) packaging, vibra packaging, skin packaging, shrink packaging, form-fill-seal packaging, Packaging machines. Quality control and safety aspects of packaging materials.

PRACTICALS:

Study of special storage structures for bulk storage of onion/potato, etc.
Study of storage behavior of different fruits and vegetables in zero energy cool chamber.
Determination of refrigeration requirements (capacity) for given quantity of fruits and vegetables.
Study of storage behaviour of different fruits and vegetables in cold room.
Study of chilling injury and storage disorders.
Study of shelf-life of fruits and vegetables in modified atmosphere packaging.
Visit to special storage structures, cold storage units.
Study of types of packaging materials, types of plastic films and their properties.
Determination of water vapour transmission rate (WVTR) and gas transmission rate (GTR) of packaging material.
Applications of packaging material for fresh fruits and vegetables, beverages, spice products.
Determination of shelf-life of fresh products in different types of packages.
Study of packaging machines - vacuum packaging machine, shrink wrapping machine, double seamer, etc. Visit to packaging unit.

TEACHING METHODS / ACTIVITIES

Lectures
Assignments (Reading/Writing)
Exposure visits
Student presentations
Group Work/seminars

RESOURCES:

Thompson A. K. (2010) Controlled atmosphere storage of fruits and vegetables (2nd Edition), CABI International, ISBN 9781845936464.
Burg S. P (Ed.) (2004) Postharvest physiology and hypobaric storage of fresh produce, CABI Publishing, ISBN 0851998011.
Coles R., McDowell D. and Kirwan M. J. (Eds.) (2003) Food Packaging Technology, Blackwell Publishing, ISBN 1841272213.
Ahvenainen R. (2003) Novel Food Packaging Techniques, CRC Press, ISBN 0849317894. Robertson G. L. (Ed.) (2010) Food packaging and shelf life: a practical guide CRC Press, ISBN 9781420078442.
Wilson C.L. (Ed.) (2007) Intelligent and active packaging for fruits and vegetables, CRC Press, ISBN 9780849391668.
Ahvenainen R. (2001) Novel Food Packaging Techniques. CRC. A.K. Thompson 2010, Controlled Atmosphere Storage of Fruits and Vegetables, CABI Publishing; 2nd revised edition.
Chattopadhyaya S. K. (2007) Handling, transportation and storage of fruits and vegetables. Gene-Tech books, New Delhi
Chandra Gopala Rao (2015) Engineering for Storage of Fruits and Vegetables; Academic Press, 1st Edition.
Mahadevaiah M and Gowramma RV. (1996) Food packaging materials. Tata McGraw Hill. Painy F.A. (1992) A handbook of food packaging. Blackie Academic.
Pantastico B. (1975) Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables. AVI Publ.

WHY THIS COURSE?

Postharvest system deals with ensuring the delivery of a crop from the time and place of harvest to the time and place of consumption, with minimum loss, maximum efficiency and returns to all concerned including grower, processors and consumer. The term 'system' represents a dynamic, complex aggregate of locally interconnected functions or operations within a particular sphere of activity. While, the term pipeline of operations refers to the functional succession of various operations but tends to ignore their complex interactions. Primary processing operations include washing/cleaning, sorting, grading, dehulling, pounding, grinding, packaging, soaking, winnowing, drying, sieving, whitening and milling and secondary operations include mixing, cooking, drying, frying, moulding, cutting, extrusion product preparation.

AIM OF THIS COURSE:

This course gives an overview of status of fruit and vegetable processing in the country, objectives and importance of preservation, important constraints and different unit operations processing industry which helps in expansion of industry and scope for further growth in this sector.

This course is organized as follows:

No	Blocks	Units
1	Importance and Thermal processes	1.Scope and Importance
		2. Thermal processes
		3. Evaporation
2.	Processing equipment and enzyme kinetics	1. Processing equipment and facilities
		2. Enzyme kinetics

LEARNING OUTCOMES

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

Unit operations of processing

Planning for domestic as well as commercial storage and processing facilities

Kinetics of growth and enzyme reaction

THEORY:

Block 1: Importance and Thermal processes

UNIT I: Processing unit- layout and establishment, processing tools. Quality requirements of raw materials for processing, preparation of raw material, primary processing: grading, sorting, cleaning, washing, peeling, slicing and blanching; minimal processing.

UNIT II: Preparation of various processed products from fruits and vegetables, flowers; role of sugar and pectin in processed products. Freezing of fruits and vegetables. Containers, equipment and technologies in canning.

UNIT III: Juice extractions, clarification and preservation, recent advances in juice processing technology, application of membrane technology in processing of juices, preparation of fruit beverages and juice concentrate. Sensory evaluation.

Block 2: Processing equipment and enzyme kinetics

UNIT I: Dehydration of fruits and vegetables using various drying technologies and equipment, solar drying and dehydration, packaging technique for processed products.

UNIT II: Quality assurance and storage system for processed products. Nutritive value of raw and processed products, plant sanitation and waste disposal. Types of horticultural and vegetables wastes and their uses, utilization of by- products from fruits and vegetables processing industries.

PRACTICALS:

Handling of harvesting equipments

Determination of physical and thermal properties of horticultural commodities

Thermal process calculations

Particle size analysis, Storage structure design
Numerical problems in freezing, drying, conveying and calculations pertaining to texture 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.

TEACHING METHODS / ACTIVITIES

Lectures
Assignments (Reading/Writing)
Exposure visits
Student presentations

RESOURCES

Cristina Ratti (2008) Advances in Food Dehydration, CRC Press, ISBN 9781420052527.
Karel M. and Lund D.B. (2003) Physical Principles of Food Preservation (2nd Edition), CRC Press. ISBN 9780824740634
Toledo R. T. (2007) Fundamentals of Food Process Engineering (3rd Edition), Springer, ISBN 9780387290195.
Rao D.G. (2010) Fundamentals of Food Engineering, PHI Learning Pvt. Ltd., ISBN 9788120338715.
Paul Singh R. and Heldman D. R. (2009) Introduction to Food Engineering (4th Edition), Academic Press, ISBN 9780123709004.
Smith P. G. (2011) Introduction to Food Process Engineering, Springer, ISBN 9781441976611.

Ph.D. Syllabus

PHM 604 SUPPLY CHAIN MANAGEMENT OF PERISHABLES

(2+0)

WHY THIS COURSE?

Supply chain management is the management of the flow of goods and services and includes all processes that transform raw materials into final products. It involves the active streamlining of a business's supply-side activities to maximize customer value and gain a competitive advantage in the marketplace. SCM represents an effort by suppliers to develop and implement supply chains that are as efficient and economical as possible. Supply chains cover everything from production to product development to the information systems needed to direct these undertakings. Because of this, effective supply chain management also requires change management, collaboration and risk management to create alignment and communication between all the entities.

AIM OF THIS 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 perishables	1. Introduction
		2. Intrinsic Issues
		3. Support system in supply chain- - Infrastructure
		4. Support system in supply chain- Finance
		5. Support system in supply chain- Government

LEARNING OUTCOMES

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

Can identify the problems related waste treatments and disposal methods

THEORY

Block 1: Supply chain management of perishables

UNIT-I: Introduction. Role of supply chain and logistics, Challenges faced in supply 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 Price risk. Management 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, Role and Relevance, Problems in Synchronization, Role of Technology; Credit Structure in India - Reserve Bank of India (RBI), NABARD; Commodity Markets, Corporates in Agribusiness.

UNIT-V: Support system in supply chain- Role of Government: Introduction; Agencies- As a Direct Player. Measures for improving supply chain and its effectiveness, involvement of organized retailers.

PRACTICAL:

Present scenario of supply chain management,

Case Study: Supply chain management of fruits and vegetables in Safal daily fresh/APMC/Reliance

Fresh/Amul/D-Mart/Spencer Retail/Vipani/Farmers Bazars/Farm Fresh/Apni Mandi, etc. based on regional importance

TEACHING METHODS / ACTIVITIES

Lectures

Assignment (Reading/Writing)

Student presentationz

RESOURCES

Chandrasekaran N. and Raghuram G. (2014) Agri-business Supply Chain Management, CRC Press, 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/>

F. Microbiology

M.Sc. Syllabus

MICRO 502

PRINCIPLES OF MICROBIOLOGY

(3+1)

Why this course?

Microbes has become a part and parcel of our lives This course is required for the future battle against infectious diseases worldwide, understanding the environmental importance of microbes and to exploit them for food production, biotechnological and industrial applications. Hence, this customized course.

Aim of the course

The main focus of our course is the potential of the organisms that cause disease and benefits in the society. You will also cover aspects of the biochemistry, physiology and genetics of microorganisms.

The course is organized as follows:

No.	Blocks	Units
1.	Scope and History of Microbiology	1. Scope of microbiology and microscopy; History routes 2. Staining and microscopy
2.	Evolutionary link of prokaryotes	1. Phylogenetic classification 2. Methods of sequencing
3.	Microbial growth, characterization	1. Microbial growth and reproduction and regulation 2. Sterilization techniques 3. Nutritional requirements for microbial growth

Theory

Block 1: Scope and History of Microbiology and Microscopy

Unit 1: Scope of microbiology; Scope of microbiology, microbes and microbiologist. Emergence of Special Fields of Microbiology.

Unit 2: History Routes; The Germ Theory of Disease, Early Studies: Pasteur's Further Contributions, Koch's Contributions, Work Toward Controlling Infections, spontaneous generation theory.

Unit 3: Staining and microscopy; Microscopy; Bright field, Dark field, Phase contrast, Confocal, Fluorescence, TEM, SEM – Working Principles and applications; Properties of light; Simple staining, differential and special staining.

Block 2: Evolutionary Link of Prokaryotes

Unit1: Phylogenetic classification; Evolutionary relationship among prokaryotes. Prokaryotes and Eukaryotes, Phylogenetic and numerical taxonomy. Species concept.

Unit2: Methods of sequencing; Use of DNA and r-RNA sequencing in classifications.

Block 3: Microbial Growth, Characterization And Regulation

Unit1: Microbial growth and reproduction

Microbial growth and reproduction-communication, bacteria, yeast and virus growth, Replication, Cultivation methods, Normal micro flora of Human body; Immune response- specific and non-specific host resistance.

Unit 2: Sterilization techniques: Physical and chemical methods of sterilisation.

Unit 3: Nutritional requirements for microbial growth: Classification of microbes: electron, energy and carbon sources.

Practicals

- Working principles and handling of different types of microscopes – Bright and Dark field microscopy
- Working principles and handling of different types of microscope- SEM and TEM
- Methods of isolation from different environments – soil, water, milk and food
- Use of selective media for isolation
- Purification techniques of bacteria and fungi
- Enumeration and Quantification techniques

- Maintenance and preservation of cultures
- Assessment of microbial quality of portable water.
- Morphological characterization of Bacteria
- Morphological characterization of fungi
- Biochemical characterization of bacteria
- Biochemical characterization of fungus

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Publication Review
- Student presentation
- Group discussion
- Case Analysis and case studies
- Guest Lectures
- Review of policy documents

Learning outcome

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

- Knowledge on historical perspective of Microbiology
- Basic knowledge on different structure of microbes

Suggested Reading

- Brock TD. 2008. Biology of microorganisms (Ed.) Madigan MT, Martinko J M, Dunlap P V, Clark DP, 12th ed. Pearson, New Jersey.
- Pelczar MJ. Jr., Chan, ECS and Kreig NR. 1997. Microbiology, Concepts and Application, 5th edition, Tata McGraw Hill, New York.
- Prescott, L.M., Harley and Klein. 2002. Microbiology 5th Edition, Tata McGraw Hill, New York.
- Bhatia, M.S.2009. Principles of Microbiology. Swastik Publishers., Delhi.
- Madigan, M. T., J. M. Martinko, P.V. Dunlap and D.P. Clark.2001. Brock biology of Microorganism 10th Ed. Pearson Education Inc, USA.
- Singh, U.S and K. Kapoor 2010. Introductory microbiology Oxford Book Company., Jaipur
- Tortora, G. J., B.J. Funke and C.L. Case. 2010. Microbiology: an introduction.10th Ed. Benjamin Cummings., New York
- Davis BD, Dulbecco R, Eisen HN and Ginsberg HS. 1990. Microbiology (4th edition). J.B.Lippincott company, Newyork.
- Alexopoulos CJ and C W. Mims. 1993. Introductory Mycology (3rd edition).Wiley Eastern Ltd, NewDelhi.
- Elizabeth Moore-Landecker. 1996. Fundamentals of the fungi. (4th edition).Prentice Hall International, Inc, London.
- Heritage,J. Evans E.G.V. and Killington, R.A. 1996. Introductory Microbiology. Cambridge University Press.
- Webster J. 1993. Introduction to Fungi.(2nd edition).Cambridge University press,Cambridge.
- Prescott LM, Harley JP and Klein DA. 2006. Microbiology (7th edition) McGraw Hill, New York.
- Schaechter M and Leaderberg J. 2004. The Desk encyclopedia of Microbiology. Elseiver Academic press, California.
- Nester, E.W., Roberts, C.V. and Nester, M.T. 1995. Microbiology: A human perspective. IWOA, U.S.A.
- Pelczar Jr, M.J. Chan, E.C.S. and Kreig, N.R. 1993. Microbiology, Mc. Graw Hill. Inc, New York.
- Holt JG and Bergey DH. 1994. Bergey's Manual of Determinative Bacteriology (9th Edition), Williams and Wilkins, Baltimore.
- Mara D. and Horan N. 2003. The Handbook of Water and waste water Microbiology. Academic Press-An imprint of Elsevier.
- Madigan M T, Bender K S, Buckley HD, Sattley WM, Stahl DA 2017. Brock Biology of Microorganisms - 15th edition. Pearson Education, USA.

Websites

- <http://www.asmscience.org>
- <http://www.asm.org>
- <http://www.microbiologyonline.org.uk>
- <http://www.microbeworld.org>

Why this course?

Microbial physiology is defined as the study of how microbial cell structures, growth and metabolism function in living organisms. Microbial physiology is important in the field of metabolic engineering and also functional genomic. The study of diversity of microbial metabolic processes & their regulation, how microbes respond to environment stress and manipulation and the genetic control of these processes are essential for their potential applications of microbial process for the production of commercial products.

Aim of the course

Microorganisms have tremendous metabolic diversity hence it's intriguing to learn how these small creatures deal with different environmental conditions and either adopt themselves to it or convert it to favourable conditions by involving different physiological processes. The contents of this course will help students how microbes can grow on substrates other than glucose, their inorganic metabolism and photosynthesis and how do they respond to the changes in environment. It will elaborate the anaerobic respiration by variety of groups of microbes and nongenetic regulation at metabolic pathways.

The course is organized as follows:

No.	Blocks	Units
1.	Scope of microbial growth and physiology	1. Structure, function and biosynthesis of cellular components
2.	Pathways and their significance; classifications	1. Growth Kinetics, cell cycle, cell division, Growth kinetics and nutritional pathways and fermentation metabolism. 2. Growth and factors affecting growth and culture systems. 3. Nutritional classification and spore formation and germination
3.	Enzymes and microbial metabolisms	1. Kinetics and Mechanism of Enzymes 2. Microbial metabolism
4.	Synthesis of macromolecules	1. Biosynthesis of macromolecules

Theory**Block 1:** Scope of Microbial Growth and Physiology

Unit 1: Structure, function and biosynthesis of cellular components: Microbial nutrition – Chemical composition of microbial cell – Structure, function and assembly of cell membrane in prokaryotes, archaea and fungi – Macro and Micro- nutrients and their physiological functions – Transport of solutes across the membrane

Block 2: Pathways and their Significance; Growth Kinetics and Nutritional Classifications

Unit 1: Growth Kinetics, cell cycle, cell division, pathways and fermentation metabolism: Microbial growth. Cell cycle and cell division. Bioenergetics -carbohydrate utilization via EMP, HMP, ED, TCA pathways, Aerobic and anaerobic respiration. Fermentative metabolism. Assimilation of nitrogen and sulphur - Oxygenic and anoxygenic photosynthesis - Mechanisms of carbon-dioxide fixation in prokaryotes. Ethanol, lactic acid, butanol, acetone and mixed acid fermentation. Fermentation of nitrogenous organic compounds Regulation of microbial metabolism.

Unit 2: Growth and factors affecting growth and culture systems: Effects of physical, chemical and other environmental factors on growth Continuous culture, Diauxic growth and Synchronous culture. Method of growth measurement. Morphogenesis and cellular differentiation.

Unit 3: Nutritional classification and spore formation and germination Metabolic diversity in photoautotrophs, photoheterotrophs, chemoautotrophs and chemoheterotrophs. Nutritional grouping/classification of microorganisms. Bacterial endospore-types, morphology, biochemistry and regulation of formation and germination

Block 3: Enzymes and Microbial Metabolisms

Unit 1: Kinetics and Mechanism of Enzymes: Enzyme kinetics: Michaelis Menten kinetics - mechanisms of

inhibition of enzyme activity - coenzymes and prosthetic groups.

Unit 2: Microbial metabolism: Methods to determine free energy of biochemical reactions - high energy compounds. Microbial metabolism: generation of ATP, reducing power, development of proton gradient and biosynthesis of ATP.

Block 4: Synthesis of Macromolecules

Unit 1: Biosynthesis of macromolecules: Biosynthesis of macromolecules – Synthesis and assembly of cell wall components; – Methods of studying biosynthesis - regulation of microbial metabolism.

Practicals

- Use of simple techniques in laboratory (Colorimetry, Centrifugation, electrophoresis and GLC, etc.).
- Determination of viable and total number of cells.
- Measurement of cell size.
- Gross cellular composition of microbial cell. Growth – Factors affecting growth.
- Study of bacterial spores and factors affecting germination.
- Enzyme activity and kinetics – calculating K_m and V_{max} of enzyme.
- Demonstration of thermos-, meso-, and psychrophilic micro-organisms.
- Production and testing of inducible enzymes in bacteria.
- Sporulation and spore germination in bacteria.
- Protoplasts formation and regeneration.
- Estimation of generation time and specific growth rate for bacteria and yeast.
- Diauxic growth curve.
- Production of synchronous cells.
- Effect of chemicals and environmental factors on bacterial growth.
- Isolation and Identification of reserve food material (Glycogen/ polyphosphates, PHB) from bacteria (*Azotobacter*, *Bacillus megaterium*).
- Growth of microorganisms on various carbon and nitrogen sources.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Publication Review
- Student presentation
- Group discussion
- Case Analysis and case studies
- Guest Lectures

Learning outcome

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

- Knowledge about cell cycle and microbial pattern
- Growth and practical training on methods to determine microbial growth

Suggested Reading

Moat, A. G. and J. W. Foster. 2002. Microbial Physiology. John Wiley & Sons, New York, USA. 11th ed. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Madigan, M.T, J.M. Martinko and J. Parker. 2006. Brock: Biology of Microorganisms, 11th ed. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

White, D. 2007. The Physiology and Biochemistry of Prokaryotes, 3rd Edition. Oxford University Press.

Downs, D. M. 2006. Understanding microbial metabolism. Annual Review of Microbiology 60, 533–559.

Hosler et al. 2006. Energy Transduction: Proton Transfer Through the Respiratory Complexes. Annual Review of Biochemistry 75, 165-187.

Okuno et al. 2008. Correlation between the conformational states of F1-ATPase as determined from its crystal structure and single-molecule rotation. PNAS 105(52): 20722-20727.

Itoh et al (2004) Mechanically driven ATP synthesis by F1-ATPase. Nature 427, 465-468.
Doelle HW. 1969. Bacterial Metabolism. Academic Press.
Gottschalk G. 1979. Bacterial Metabolism. Springer Verlag.
Nelson DL and Cox MM. 2017. Lehninger, Principles of Biochemistry, 4th Edition, W.H. Freeman & Company, 2004. (T1)
Voet D and Voet JG. 2002. Fundamentals of Biochemistry, Upgrade Edition, Wiley.

Journals

- Journal of Bacteriology.
- Advances in Microbial Physiology.
- Soil Biology and Biochemistry.
- Journal of Applied Bacteriology.
- Applied and Environmental Microbiology.
- Microbiology.

Websites

- <http://www.asmscience.org>
- <http://www.asm.org>
- <http://www.microbiologyonline.org.uk>
- <http://www.microbeworld.org>
- <http://www.textbookofbacteriology.net>
- <https://www.e-education.psu.edu>
- <http://www.ncbi.nlm.nih.gov/pubmed/12050002>
- <http://www.journals.elsevier.com/bba-bioenergetics/>
- <http://www.bmb.leeds.ac.uk/illingworth/oxphos>
- <http://www.atpsynthase.info/>
- <https://ocw.um.edu.my/course/view.php?id=67>
- <https://mic.microbiologyresearch.org/content/journal/micro/10.1099/mic.0.037143-0>

Why this course?

Microbial Genetics has traditionally been a field of basic science research as microorganisms offer several features that facilitate the study of evolutionary process, understanding the genotype and its expression system. Students also hone their abilities to read, understand and critically evaluate research articles as well as improve presentation skills.

Aim of the course

This course is designed to provide an understanding of the fundamentals of genetic processes in prokaryotes and eukaryotes. The study of microbial genetics has provided much of the understanding of fundamental genetic processes for all organisms, especially through the use of in vivo and in vitro genetic tools.

The course is organized as follows:

No.	Blocks	Units
1.	Introduction to microbial genetics	1. Historical perspectives of microbial genetics 2. Genome of prokaryote, eukaryote (fungi) and virus 3. Genetic elements - chemical structure and property, enzymes associated and replication 4. Extra-chromosomal DNA in bacteria and eukaryotic cells
2.	Gene expression and regulation	1. Introduction to Gene structure and expression 2. Regulation of gene expression
3.	Mutation, genetic recombination	1. Principles of mutation and types and sequencing 2. Mutagens and their mode of action 3. DNA damage – DNA repair mechanisms in bacteria 4. Genetic recombination in bacteria 5. Gene Sequencing

Theory**Block 1: Introduction to Microbial Genetics**

Unit 1: Historical perspectives of microbial genetics: Introduction to Microbial genetics; Historically important events and major contributions of scientists in the field of Microbial genetics; Terminologies employed in microbial genetics and definitions; Nucleic acid – overview DNA, RNA.

Unit 2: Genome of prokaryote, eukaryote (fungi) and virus: Bacterial genome Eukaryotic genome; Viral genome; Difference between prokaryotic and eukaryotic genome; Mechanisms and role of prokaryotic genome- an overview.

Unit 3: Genetic elements - chemical structure and property, enzymes associated and replication: Structure of DNA – A form, B form, Z form; RNA- tRNA, mRNA, rRNA; Role and Replication of DNA and RNA; Enzymes involved in Replication and its role.

Unit 4: Extra-chromosomal DNA in bacteria and eukaryotic cells: Plasmids, Mitochondrial DNA, Chloroplast DNA – structure and function.

Block 2: Gene Expression and Regulation

Unit 1: Introduction to gene structure and expression: Gene structure and expression, principles of operon, gene expression in prokaryote and eukaryotes, intron and exons, post transcriptional modifications.

Unit 2: Regulation of gene expression: Regulation of gene expression, negative expression (lac operon and trp operon), positive regulation (cAMP).

Block 3: Mutation, Genetic Recombination and Sequencing

Unit 1: Principles of mutation and types: Principles of mutation, spontaneous and induced mutation, different types of mutations, selection principles of mutants.

Unit 2: Mutagens and their mode of action: Mutagens and their mode of action, transposable elements and insertion sequences.

Unit 3: DNA damage - DNA repair mechanisms: DNA damage, DNA repair mechanisms in bacteria.

Unit 4: Genetic recombination in bacteria: Genetic recombination in bacteria, mechanisms of recombination, transformation, conjugation, transduction.

Unit 5: Gene sequencing: Gene cloning and gene sequencing. Impact of gene cloning, polymerase chain reaction, DNA sequencing, recombinant DNA technology.

Practicals

- Isolation of genomic DNA from pure cultures of bacteria and fungi.
- Visualization of mega plasmids of bacteria.
- Isolation of bacterial plasmids and Plasmid curing.
- Qualitative and quantitative assay of DNA by spectrometry and gel-electrophoresis.
- Inducing mutation by chemicals, physical and biological agents.
- Transformation and selection of transformants.
- Amplification of gene of interest by PCR – cloning and expression.
- Isolation of metagenomic DNA from environmental samples.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation
- Group work in practical
- Field visit
- Case studies

Learning outcome

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

- Identify and distinguish genetic regulatory mechanisms at different levels
- Plan basic experiments in Microbial genetics
- Describe and summarize experimental work in a correct way.

Suggested Reading

Brown TA. 2001. Gene Cloning and DNA Analysis: An Introduction. Fourth Edition. Blackwell Science Inc., Oxford, UK.

Levin B. 2002. Gene VIII. Oxford Univ. Press, New York. p.990.

Maloy SR, Cronan JE, Freifelder D. 2008. Microbial Genetics - second edition. Narosa Publishing house, New Delhi. p. 525.

Omoto CK and Lurquin PF. 2004. Genes and DNA: A beginner's guide to genetics and its applications. Columbia University Press, USA.

Sambrook J, Fritsch EF, Maniatis T. 2000. Molecular Cloning: A laboratory Manual. Third Edition. Cold Spring Harbor Press, New York.

Streips UN, Yasbin RE. 2006. Modern Microbial Genetics. Wiley – Liss. John Wiley & sons, Inc. Publication, NY.

Birge EA. 1981. Bacterial and Bacteriophage Genetics. Springer Verlag.

Gardner JE, Simmons MJ and Snustad DP. 1991. Principles of Genetics. John Wiley & Sons.

Lewin B. 1999. Gene. Vols. VI-IX. John Wiley & Sons.

Maloy SR, Cronan JE and Friedfelder D. 2008. Microbial Genetics. Narosa.

Scaife J, Leach D and Galizzi A 1985. Genetics of Bacteria. Academic Press. William Hayes 1981. Genetics of Bacteria. Academic Press.

Strips UN, Yasbin RE *2006. Modern Microbial Genetics. Wiley-Liss, NY.

Websites

http://highered.mcgraw-hill.com/sites/0072552980/student_view0/chapter9/

http://highered.mcgrawhill.com/sites/0072835125/student_view0/animations.html

<http://cwx.prenhall.com/brock/>

<http://www.cliffsnotes.com/sciences/biology/microbiology>

<http://plato.acadiau.ca/courses/biol/Microbiology/home.HYPERLINK>

<http://plato.acadiau.ca/courses/biol/Microbiology/home.html>

<http://www.learner.org/courses/biology/index.html>

Why this Course?

Understanding the function of the soil ecosystem in relation to ever changing soil conditions is key to understanding the basic mechanisms of soil productivity. This is important in light of the urgency to change agricultural practices and also the problems of xenobiotic compounds in soils. The possible perturbations caused by pollution, intense agricultural practices or changing land use—are of major concern. The possibility of involvement of nonculturable or minute cell fractions requires innovative research using molecular biological techniques. Information on the effects of different root parts versus bulk soil is interesting. Role of microorganisms in biogeochemical cycles and their interactions decide the nutrients available to crops. The rhizosphere—the micro environment around plant roots houses intense biological, physical and geochemical activity distinguishing it from surrounding soil. Diversity, distributions, activities and interactions of innumerable organisms affect and are affected by availability of energy and nutrients, soil-water content and rhizosphere redox states. Soil food webs and nutrient cycling in agro ecosystems is of prime concern.

Aim of the course

- To help unlock and harness the potential of microorganisms in soil.
- To know the potential benefit of consortia of microorganisms to protect plants from different stresses.
- To study the role of microorganisms in the ecosystem functioning, nutrient cycling and biogeochemical processes including soil enzymes, through their metabolic activity and interactions.

The course is organized as follows:

No.	Blocks	Units
1.	Developments in soil Microbiology and Soil parameters Factors affecting soil microflora	1. Historical prospective of soil microbiology. 2. Ecology of soil microbiology
2.	Microbiology and Biochemistry of	1. Plant parts and soil interface interaction Plant parts
3.	Role of microorganisms in nutrient	1. Microbial transformations of various biocycle nutrients 2. Microbial degradation of organic matter 3. Microbial diversity 4. Role of microorganisms in biodegradation of xenobiotics and pesticides.

Theory

Block 1: Developments in Soil Microbiology and Soil Parameters

Unit 1: Historical prospective of soil microbiology. Factors affecting soil microflora. Landmarks in the history of soil microbiology. Abiotic factors (physical and chemical) affecting soil microflora as pH, chemicals, moisture, air, temperature etc.

Unit 2: Ecology of soil microbiology: Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Microbial interactions: unculturable soil biota.

Block 2: Microbiology and Biochemistry of Plant Parts

Unit 1: Plant parts and soil interface interaction: Microbiology and biochemistry of root-soil interface; phyllosphere, plant growth promoting rhizobacteria, soil enzyme activities and their importance.

Block 3: Role of Microorganisms in Nutrient Biocycle

Unit 1: Microbial transformation of various nutrients: Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Siderophores and antimicrobials.

Unit 2: Microbial degradation of organic matter: Biochemical composition and biodegradation of soil organic matter and crop residues.

Unit 3: Microbial diversity: Endophytic microorganisms Mycorrhizae, types and role in phosphate mobilization. Potassium releasing bacterium. Microbes in biotic and abiotic stress management.

Unit 4: Role of microorganisms in biodegradation of xenobiotics and pesticides: Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures: Biotic factors in soil development.

Practicals

- Determination of soil microbial population
- Determination of Soil microbial biomass
- Decomposition studies in soil, Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification
- N₂ fixation, S oxidation, P solubilization and mineralization of other micro nutrients
- Study of rhizosphere effect
- Microbial diversity Endophytic microorganisms
- Mycorrhizae, types and role in phosphate mobilization Potassium releasing bacterium
- Microbes in biotic and abiotic stress management

Teaching methods/activities

- Lectures. To use ppt and video clippings whenever necessary based on the topics that are hard to understand.
- The students must be assigned either in individual or in groups to identify the soils and crops grown and must get respective soil samples and plants for analyzing the microorganisms. They must subject the culture for various analysis depending upon the culture such a nitrogen fixing ability, phosphate solubilising property etc.
- Testing their efficiency through growth studies

Learning outcome

- Students will become familiar to the types of microbes in soil and their association with plants.
- The exclusive role of microorganisms in plant growth can be thoroughly understood.

Suggested Reading

Paul EA. 2015. Soil Microbiology, Ecology and Biochemistry. Elsevier

Jan Dirk Van Elsas, Trevors JT and Elizabeth M.H. Wellington, 1997. Modern Soil Microbiology. Marcel Dekker, Inc.

Paul EA. 2007. Soil Microbiology and Biochemistry 3rd Edition. Academic Press.

Cardon ZG and Whitbeck JL. 2007. The Rhizosphere An Ecological Perspective. Academic Press.

Schulz BJE, Boyle CJC and Sieber TN (Eds). 2006. Microbial Root Endophytes. Pub Springer.

Magesin R and Schinner F. (Eds). 2005. Manual of soil analysis monitoring and assessing soil Bioremediation. Pub: Springer.

Pinton R, Varanini Z and Nannipieri P. The Rhizosphere Biochemistry & organic substances at the soil-plant interface. Pub: CRC Press.

Prasad TV. 2011. A Text Book of Soil Microbiology. Dominant Publishers & Distributors, New Delhi.

Mukerji KG, Manoharachary C and Singh J. 2006. Microbial activity in the Rhizosphere. Pub: Springer.

Journals

- European Journal of Soil biology.
- Canadian Journal of Microbiology
- Annual Review of Microbiology
- Journal of the Indian Society of Soil Science.
- Soil Biology and Biochemistry
- Applied soil ecology

Websites

- www.nature.com
- www.microbiologysociety.org
- www.sare.org

Why this course?

To give practical knowledge on fermentation and to develop fermentation for industrial application. Hence, this customised course.

Aim of the course

The aim is to teach students about industrially useful microorganisms and use of fermentor for the production of various primary and secondary metabolites. The course is organized as follows:

No.	Blocks	Units
1.	Scope of Microbial Technology and Fermentation Metabolism	1. Microbial Biotechnology 2. Fermentation Metabolism 3. Fermenter/bioreactor design and operation 4. operation 5. Fermentation system
2.	Recombinant products	1. Production of recombinant
3.	Microbial conversion and their product formation solvent	1. Industrial production of beverages, acids and 2. New tools and recent advances in microbial biotechnology

Theory**Block 1: Scope of Microbial Technology and Fermentation Metabolism**

Unit 1: Microbial Biotechnology: Introduction, Scopes, historical development, application and challenges.

Unit 2: Fermentation Metabolism: Fermentative metabolism, isolation, preservation screening and genetic improvement of industrially important microbes; Microbial growth kinetics.

Unit 3: Fermenter/bioreactor design and operation: Fermenters – types of fermenter, stirred tank reactor, bubble column reactor, airlift reactor, packed bed reactor, fluidized bed reactor and trickle bed reactor, agitation and aeration in a reactor, mass transfer. Foam formation and control.

Unit 4: Fermentation system: Types, Batch, Fed batch and continuous fermentation- multistage system. Solid state fermentation, Overproduction of primary and secondary metabolites e.g. amino acids, organic acids, alcohols, enzymes, organic solvents, antibiotics, etc. Immobilization of enzymes; and cells; Scale-up principles; Down-stream processing, etc.

Block 2: Recombinant Products

Unit 1: Production of recombinant: Current advances in production of antibiotics, vaccines, and biocides; Steroid transformation; Bioprocess engineering; Production of recombinant DNA products, Immobilization techniques.

Block 3: Microbial Conversion and their Product Formation

Unit 1: Industrial production of beverages, acid and solvent: Production of alcohol (ethanol, wine and beer) and improvement by genetic engineering. Microbial production of acids (citric, acetic and gluconic acid) solvents (glycerol acetone and butanol) aminoacids (lysine and glutamic acid).

Unit 2: New tools and recent advances in microbial biotechnology: Concept of probiotics and applications of new tools of biotechnology for quality feed/food production; Microorganisms and proteins used in probiotics; Lactic acid bacteria as live vaccines; Bioconversion of substrates, anti-nutritional factors present in feeds; Microbial detoxification of aflatoxins; Microbial polysaccharides: fermentative production of xanthan gums. Bacterial bioplastics, genetic engineering of microorganisms for the production of poly-3 hydroxyalkanoates. Single cell protein, Bio-insecticides; Bio-fertilizers; Waste as source of energy/food Microbiologically produced food, colours, and flavours. Retting of flax. Recent advances in microbial biotechnology.

Practicals

- Isolation and maintenance of industrially important microbes
- Production of alcohol
- Production of beer
- Production of citric acid
- Production of lactic acid

- Standardization of physical factors for the higher production of citric acid
- Production and assay of antibiotics
- Production of pullulan
- SCP production
- Study of bioreactors and their operation

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Publication Review
- Student presentation
- Group discussion
- Case Analysis and case studies
- Guest Lectures

Learning outcome

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

- Better knowledge on industrially important microbes
- Important downstreaming processes followed for product development

Suggested Reading

Cruger W and Cruger A. 2004. Biotechnology - A Textbook of Industrial Microbiology. 2nd Ed. Panima.

Ward OP. 1989. Fermentation Biotechnology. Prentice Hall.

Wiseman A. 1983. Principles of Biotechnology. Chapman & Hall

Peppler HJ and Perlman D.1979. Microbial Technology. 2nd Ed. Academic Press.

Websites

- <http://www.asmscience.org>
- <http://www.asm.org>
- <http://www.microbiologyonline.org.uk>
- <http://www.microbeworld.org>

Why this course?

Food Microbiology focuses on a wide variety of current research on microbes that have both beneficial and deleterious effects on the safety and quality of foods, and are thus a concern of public health. This course, food microbiology focuses specifically on issues of food spoilage caused by the presence of food-borne pathogens. Students are instructed in methods of sanitation and preservation during food preparation and processing.

Aim of the course

To familiarize the students with recent advances in food microbiology including fermented foods, dairy, food preservation, detection of food-borne diseases, their control measures.

The course is organized as follows:

No.	Blocks	Units
1	Historical Perspective and Scope	1. Importance and significance of Microbiology in relation to food microorganisms in food 2. Factors of special significance in Food Microbiology 3. Microbial spoilage of different types of foods
2	Fermentation and Food Preservation	1. Food fermentation methods 2. Preservatives and preservation methods
3	Food safety and Quality Management Systems	1. Advanced techniques in detecting food-borne pathogens and toxins.

Theory

Block 1: Historical Perspective and Scope of Microbiology in Relation to Food

Unit 1: Importance and significance of microorganisms in food Introduction and scope; Food Microbiology Important microorganisms in food and their sources. Importance and significance of microorganisms in food.

Unit 2: Factors of special significance in Food Microbiology Intrinsic and extrinsic factors influencing microbial growth in foods; Spores and their significance; Indicator organisms and Microbiological criteria.

Unit 3: Microbial spoilage of different types of foods Microbial spoilage of meat, milk, fruits, vegetables and their products. Food-borne pathogens (bacteria, fungi and viruses) and intoxication.

Block 2: Fermentation and Food Preservation Methods

Unit 1: Food fermentation Fermented dairy, vegetable, meat products.

Unit 2: Preservatives and preservation methods Physical methods, chemical preservatives and natural antimicrobial compounds. Biologically based preservation systems. Foods for Specified Health Probiotic bacteria; Bifidus factor. Bacteriocins and their applications; Pre-, probiotics and symbiotics. Microbes as food single cell protein.

Block 3: Food Safety and Quality Management Systems

Unit 1: Advanced techniques in detecting food-borne pathogens and toxins Food safety and Quality Management Systems- General principles of food safety risk management, Recent concerns on food safety- Safe food alternatives (Organic foods), Good agricultural Practices (GAP), Food Indicators of water and food safety and quality Advanced techniques in detecting food-borne pathogens and toxins. HACCP (Hurdle technology and Hazard analysis. Critical control point) CODEX, FSSAI (Food Safety and Standard Authority of India) systems in controlling microbiological hazards in foods. Food safety regulations

Practicals

- Statutory, recommended and supplementary tests for microbiological analysis of various foods
- Infant foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers, normal, spoiled, processed, fermented food and water
- Testing of antimicrobial agents
- Analysis of water
- HACCP Plan
- Visit to Food processing Industries

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation
- Group Work in Practical
- Visit to Food processing Industries

Learning outcome

With this course the students are expected to be able to learn

- Important microorganisms in food and their sources.
- Various Factors of special significance in Food Microbiology.
- Biologically based preservation systems of foods.
- Advanced techniques in detecting food-borne pathogens and toxins.

Suggested Reading

- Bibek Ray. 1996. Fundamentals of Food Microbiology. CRC Press.
- Frazier W.C. and Westhoff D.C. 1991. Food Microbiology. 3rd Ed. Tata McGraw Hill.
- George J Banwart. 1989. Basic Food Microbiology. AVI.
- James M Jay. 1987. Modern Food Microbiology. CBS.
- Peppler H.J. and Perlman D. 1979. Microbial Technology. 2nd Ed. Academic Press.
- Adams, M.R., and M. O. Moss 1996. Food Microbiology, New Age International (Rt) Ltd., New Delhi.
- Frazier, W.C. and D.C. Westhoff, 1988. Food Microbiology (Reprint 1995), Tata McGraw Hill Publishing Ltd., New Delhi.
- James M. Jay., Loessner, M.J. and Golden D.A. 2005. Modern Food Microbiology, Seventh edition.
- Verma, L.K. and Joshi, V.K. 2000. Post Harvest Technology of Fruits and Vegetables, Tata McGraw Hill Publication.
- Bhunia AK. 2008. Foodborne Microbial Pathogens- Mechanisms and Pathogenesis, Food Science text Series, Springer International, New York, USA.
- Benwart, G.J. 1987. Basic Food Microbiology, CBS Publishers & Distributors, New Delhi.
- Deak, T. and Beuchat LR. 1996. Hand Book of Food Spoilage Yeasts, CRC Press, New York.
- Doyle, M.P. and Beuchat, L. R. 2007. Food Microbiology- Fundamentals and Frontiers, ASM Press.
- Garbutt, J., 1997. Essentials of Food Microbiology, Arnold – International Students edition, London.
- Marriott, N.G. and Gravani R. B. 2006. Principles of Food Sanitation, Food Science text Series, Springer International, New York, USA.

Websites

- <https://www.journals.elsevier.com/food-microbiology>
- <https://www.nature.com/subjects/food-microbiology>
- <https://www.frontiersin.org/journals/microbiology/sections/food-microbiology>
- <https://www.sciencedirect.com/journal/food-microbiology>

Ph.D. Syllabus

MICRO 603 RECENT DEVELOPMENTS IN SOIL MICROBIOLOGY

(2+0)

Why this Course?

Directly or indirectly the waste of human and other animals, their bodies, and the tissues of plants are dumped onto or buried in the soil. It is the microbes that make these changes –the conversion of organic matter in to simple organic substances that provide the nutrient material for the plant and agriculture world. Thus microorganisms play a vital role in maintaining life on earth. The prerequisite Basic Sciences: Microbiology for this class is SOIL. To be completely prepared for this class a course taken in Microbiology is very useful.

Aim of the course

To make students learn the latest trends in soil microbiology like diversity, biological control and bioremediation. The course is organized as follows:

No.	Blocks	Units
1.	Recent developments in soil	1. Ecology and microorganisms diversity microbiology 2. Role of microorganisms in soil 3. Bioremediation

Theory

Block 1: Recent Developments in Soil Microbiology

Unit 1: Ecology and microorganisms diversity: Molecular ecology and biodiversity of soil microorganisms; Survival and dispersal of microorganisms. Interaction between agricultural chemicals, pollutants and soil microorganism

Unit 2: Role of microorganisms in soil: successions and transformation of organic matter; Role of microorganisms in soil fertility. Soil health and quality: Microbial indicators

Unit 3: Bioremediation

Bioremediation of polluted soils; Biological control. Other topics of current interest.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Seminar presentation by students.
- Case studies

Learning outcome

With this course, the students are expected to be able to learn

- Latest trends in soil microbiology like diversity, biological control and bioremediation.

Suggested Reading

Websites

- <https://www.springer.com/in/book/9789811073793>
- https://www.researchgate.net/publication/322952969_Advances_in_Soil_Microbiology_Recent_Trends_and_Future_Prospects_Volume_2_Soil-Microbe-Plant_Interaction
- Selected articles from journals.

Why this Course?

The activities of the microorganisms at large in nature/ environment are considered in this course. Microbes play far more important roles in nature than their small sizes would suggest. In order to evaluate the roles of microorganisms in ecosystems, it is essential to understand the precise natural habitats and how their activities can be explored.

Aim of the course

To apprise the students about the role of microbiology in environment management for sustainable eco-system and human welfare.

The course is organized as follows:

No.	Blocks	Units
1.	Recent environmental issue	1. Basic concepts and environmental issues 2. Methodology of environmental management 3. Microbial waste treatment.
2.	Energy harnessing from organic	1. Pollution through conventional fuel waste 2. Renewable sources of energy.
3.	Treatment of waste for safe disposal.	1. Disposal of domestic and industrial wastes 2. Global environmental problems

Theory

Block 1: Recent Environmental Issue

Unit 1: Basic concept and environmental issues: Types of environmental pollution; problems arising from high-input agricultural residues. Air and water pollution.

Unit 2: Methodology of environmental management: Waste water treatment -physical, chemical, biological and microbial processes; need for water and natural resource.

Unit 3: Microbial waste treatment: Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents, etc.; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc.); anaerobic processes: digestion, filtration, etc.

Block 2: Energy Harnessing from Organic Waste

Unit 1: Pollution through conventional fuel: Conventional fuels and their environmental impact.

Unit 2: Renewable sources of energy: Energy from solid waste; ; biogas; land filling, microbial hydrogen production; use of agro-industrial waste, agricultural waste for sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture, etc.

Block 3: Treatment of Waste for Safe Disposal

Unit 1: Disposal of domestic and industrial wastes: Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by micro-organisms.

Unit 2: Global environmental problems: Ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; Microbial and biotechnological approaches for the management of environmental problems.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Seminar presentation by students.
- Case studies

Learning outcome

With this course, the students are expected to be able to learn

- Latest trends in environmental microbiology like Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by micro-organisms

– Renewable and non-Renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas; land filling, microbial hydrogen production

Suggested Reading

Evans GM and Furlong JC. 2002. Environmental Biotechnology: Theory and Application. Wiley International.

Jordening HJ and Winter J. 2006. Environmental Biotechnology: Concepts and Applications. Wiley-VCH Verlag.

Websites

- <https://www.springer.com/series/11961>
- <http://microbiology.ucsc.edu>.
- <http://www.asm.org>

II. Supporting Courses

S.No.	Course No.	Course Title	Credits
II	Supporting Courses		06
A	Statistics		
1	STAT 502	Statistical Methods for Applied Sciences	3+1
2	STAT 511	Experimental Designs	2+1
3	STAT 512	Basic Sampling Techniques	2+1
4	STAT 521	Applied Regression Analysis	2+1
5	STAT 522	Data Analysis Using Statistical Packages	2+1
6	STAT 555	Bioinformatics	2+0
7	STAT 605*	Modeling Techniques for Forecasting	2+1
B	Computer Applications		
1	MCA 501	Computers Fundamentals and Programming	2+1
2	MCA 511	Introduction to Networking and Internet Applications	1+1
3	MCA 512	Information Technology in Agriculture	2+0
4	MCA 601*	Spatial informatics, GIS and Remote Sensing Techniques	1+1
C	Biochemistry		
1	BIOCHEM 501	Basic Biochemistry	2+1
2	BIOCHEM 505	Techniques in biochemistry	2+2
3	BIOCHEM 507	Plant Biochemistry	2+1
4	BIOCHEM 603*	Biochemistry of Biotic and Abiotic Stresses	3+0
5	BIOCHEM 604*	Frontier Topics in Biochemistry	2+0

**Starred courses are Ph.D. courses. M.Sc. students are not permitted to register.*

A. STATISTICS

M.Sc. Syllabus

STAT 502

STATISTICAL METHODS FOR APPLIED SCIENCES

(3+1)

Objective

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

UNIT I

Box-plot, Descriptive statistics, Exploratory data analysis, Theory of probability, Random variable and mathematical expectation.

UNIT II

Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions.

UNIT III

Introduction to theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression coefficients, Coefficient of determination, Fitting of quadratic models.

UNIT IV

Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomness of a sequence. Median test.

UNIT V

Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

Practical

Exploratory data analysis, fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F; Confidence interval estimation and Correlation and regression analysis, fitting of Linear and Quadratic Model; Non- parametric tests. ANOVA: One way, Two Way, SRS

Suggested Readings

Goon AM, Gupta MK & Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.

Goon AM, Gupta MK & Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.

Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley.

Hogg RV & Craig TT. 1978. Introduction to Mathematical Statistics. Macmillan.

Morrison DF. 1976. Multivariate Statistical Methods. McGraw Hill.

Robert V. Hogg, Joseph W. McKean, Allen T. Craig (2012). Introduction to Mathematical Statistics (7th Edition)

Siegel S, Johan N & Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley.

T.W. Anderson (2009) An Introduction to Multivariate Statistical Analysis, 3rd Ed. John Wiley

<http://freestatistics.altervista.org/en/learning.php>. <http://www.statsoft.com/textbook/stathome.html>.

Objective

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

Theory**UNIT I**

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments; Analysis with missing data; Split plot and strip plot designs.

Suggested Readings

Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.
Douglas C. Montgomery (2012). Design and Analysis of Experiments, 8th Ed. John Wiley.
Federer WT. 1985. Experimental Designs. MacMillan.
Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.
Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley.
www.drs.icar.gov.in.

Objective

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

Theory**UNIT I**

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

UNIT II

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

UNIT III

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

UNIT IV

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

Practical

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

Suggested Readings

Cochran WG. 1977. Sampling Techniques. John Wiley.

Murthy MN. 1977. Sampling Theory and Methods. 2nd Ed. Statistical Publ. Soc., Calcutta.

Singh D, Singh P & Kumar P. 1982. Handbook on Sampling Methods. IASRI Publ.

Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. Sampling Theory of Surveys with Applications. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.

William. G. Cochran. 2007. Sampling Techniques. John Wiley & Sons Publication

William G. Cochran (2007). Sampling Techniques, 3rd Edition. John Wiley & Sons Publication

Objective

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multi collinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

Theory**UNIT I**

Introduction to correlation analysis and its measures, Correlation from grouped data, correlation, Rank correlation, Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

UNIT II

Problem of correlated errors; Auto correlation; Heteroscedastic models, Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multi collinearity, Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

UNIT III

Diagnostic of multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation.

UNIT IV

Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

Practical

Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection; Handling of correlated errors, multi collinearity; Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

Suggested Readings

David G. Kleinbaum, Lawrence L. Kupper, Azhar Nizam(2007). Applied Regression Analysis and Other Multivariable Methods (Duxbury Applied) 4th Ed.

Draper NR & Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.

Ezekiel M. 1963. Methods of Correlation and Regression Analysis. John Wiley.

Kleinbaum DG, Kupper LL, Muller KE & Nizam A. 1998. Applied Regression Analysis and Multivariable Methods. Duxbury Press.

Koutsoyiannis A. 1978. Theory of Econometrics. MacMillan.

Kutner MH, Nachtsheim CJ & Neter J. 2004. Applied Linear Regression Models. 4th Ed. With Student CD. McGraw Hill.

Objective

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students a hands on experience in the analysis of their research data. This course is useful to all disciplines.

Theory**UNIT I**

Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II

Test for normality; Testing of hypothesis using chi-square, t and F statistics and Z-test.

UNIT III

Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

UNIT IV

Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

UNIT V

Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

Practical

Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data. Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, one-way analysis of variance, Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components, Linear regression, Multiple regression, Regression plots, Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis - obtaining principal component.

Suggested Readings

- Anderson CW & Loynes RM. 1987. The Teaching of Practical Statistics. John Wiley.
- Atkinson AC. 1985. Plots Transformations and Regression. Oxford University Press.
- Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmont, California.
- Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall.
- Chatfield C. 1995. Problem Solving: A Statistician's Guide. Chapman & Hall.
- Cleveland WS. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.
- Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
- Erickson BH & Nosanchuk TA. 1992. Understanding Data. 2nd Ed. Open University Press, Milton Keynes.
- Snell EJ & Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman & Hall.
- Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.
- Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, Conn.
- Velleman PF & Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.
- Weisberg S. 1985. Applied Linear Regression. John Wiley.
- Wetherill GB. 1982. Elementary Statistical Methods. Chapman & Hall.
- Wetherill GB. 1986. Regression Analysis with Applications. Chapman & Hall.
- William S. Cleveland (1994) The Elements of Graphing Data, 2nd Ed., Chapman & Hall
- <http://freestatistics.altervista.org/en/learning.php>. <http://freestatistics.altervista.org/en/stat.php>.
- http://www.cas.lancs.ac.uk/glossary_v1.1/main.html. <http://www.stat.sc.edu/~grego/courses/stat706/>.
- www.drs.icar.gov.in.

Objective

Bioinformatics is a new emerging area. It is an integration of Statistics, Computer applications and Biology. The trained manpower in the area of Bioinformatics is required for meeting the new challenges in teaching and research in the discipline of Agricultural Sciences. This course is meant to train the students on concepts of basic biology, statistical techniques and computational techniques for understanding bioinformatics principals.

Theory**UNIT I**

Basic Biology: Cell, genes, gene structures, gene expression and regulation, Molecular tools, nucleotides, nucleic acids, markers, proteins and enzymes, bioenergetics, single nucleotide polymorphism, expressed sequence tag. Structural and functional genomics: Organization and structure of genomes, genome mapping, assembling of physical maps, strategies and techniques for genome sequencing and analysis.

UNIT II

Computing techniques: OS and Programming Languages – Linux, perl, bioperl,python, biopython,cgi, MySQL, phpMyAdmin; Coding for browsing biological databases on web, parsing & annotation of genomic sequences; Database designing; Computer networks – Internet, World wide web, Web browsers– EMBnet, NCBI; Databases on public domain pertaining to Nucleic acid sequences, protein sequences, SNPs, etc.; Searching sequence databases, Structural databases.

UNIT III

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack-knifing; Hidden Markov Models; Bayesian estimation and Gibbs sampling;

UNIT IV

Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis, Approaches to EST analysis; Pairwise alignment techniques: Comparing two sequences, PAM and BLOSUM, Global alignment (The Needleman and Wunsch algorithm), Local Alignment (The Smith-Waterman algorithm), Dynamic programming, Pairwise database searching; Sequence analysis– BLAST and other related tools, Multiple alignment and database search using motif models, ClustalW, Phylogeny; Databases on SNPs; EM algorithm and other methods to discover common motifs in biosequences; Gene prediction based on Neural Networks, Genetic algorithms, Computational analysis of protein sequence, structure and function; Design and Analysis of microarray/RNAseqexperiments.

Suggested Readings

- Baldi P & Brunak S. 2001. Bioinformatics: The Machine Learning Approach. 2nd Ed. (Adaptive Computation and Machine Learning). MIT Press.
- Baxevanis AD & Francis BF. (Eds.). 2004. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. John Wiley.
- Bergeron BP. 2002. Bioinformatics Computing. Prentice Hall.
- Duda RO, Hart PE & Stork DG. 1999. Pattern Classification. John Wiley.
- Ewens WJ & Grant GR. 2001. Statistical Methods in Bioinformatics: An Introduction (Statistics for Biology and Health). Springer.
- Graham B. Zweig, J. Buffett, WE. 2006. The Intelligent Investor: The Definitive Book on Value Investing. A Book of Practical Counsel, Revised Edition
- Hunt S & Livesy F. (Eds.). 2000. Functional Genomics: A Practical Approach (The Practical Approach Series, 235). Oxford Univ. Press.
- Jones NC & Pevzner PA. 2004. An Introduction to Bioinformatics Algorithms. MIT Press.
- Koski T & Koskinen T. 2001. Hidden Markov Models for Bioinformatics. Kluwer.
- Krane DE & Raymer ML. 2002. Fundamental Concepts of Bio-informatics. Benjamin / Cummings.
- Krawetz SA & Womble DD. 2003. Introduction to Bioinformatics: A Theoretical and Practical Approach.

Humana Press.

Lesk AM. 2002. Introduction to Bio-informatics. Oxford Univ. Press.

Percus JK. 2001. Mathematics of Genome Analysis. Cambridge Univ. Press.

Sorensen D & Gianola D. 2002. Likelihood, Bayesian and MCMC Methods in Genetics. Springer.

Tisdall JD. 2001. Mastering Perl for Bioinformatics. O'Reilly & Associates.

Tisdall JD. 2001. Beginning Perl for Bioinformatics. O'Reilly & Associates.

Wang JTL, Zaki MJ, Toivonen HTT & Shasha D. 2004. Data Mining in Bioinformatics. Springer.

Wu CH & McLarty JW. 2000. Neural Networks and Genome Informatics. Elsevier.

Wunschiers R. 2004. Computational Biology Unix/Linux, Data Processing and Programming. Springer.

Ph.D. Syllabus

STAT 605

MODELING TECHNIQUES FOR FORECASTING

2+1

Objective

This is an advanced course in Statistical Methods that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in the area of empirical and mechanistic models and nonlinear estimation and the replications in different disciplines of agricultural sciences.

Theory

UNIT I

Empirical and mechanistic models. Nonlinear growth models: monomolecular, logistic, Gompertz, Richards. Applications in agriculture and fisheries.

UNIT II

Nonlinear estimation: Least squares for nonlinear models, Methods for estimation of parameters like linearization, Steepest, and Levenberg-Marquardt's Parameterization.

UNIT III

Two-species systems. Lotka-Volterra, Leslie-Gower and Holling-Tanner non-linear prey-predator models. Volterra's principle and its applications. Gauss competition model.

UNIT IV

Compartmental modelling - First and second order input-output systems, Dynamics of a multivariable system.

UNIT V

Forecasting techniques with special reference to agriculture. Forecast based on time series data: exponential smoothing, Box - Jenkins approach and non-linear models. Forecast models using weather parameters, crop weather relationships and their use in yield forecast. Forecast using plant characters.

UNIT VI

Forecast surveys, between-year models (regression model, Markov chain probability model and group method of data handling) and within-year models. Agro-meteorological models: climatic water balance model and crop yield assessment. Forewarning of crop pests and diseases. Application of remote sensing techniques in forecasting. Use of ANN in forecasting.

Practical

Fitting of mechanistic non-linear models; Application of Schaefer and Fox non-linear models; Fitting of compartmental models. Fitting of forecast models using weather parameters. Time series analysis: plots, decomposition, stationarity tests, exponential smoothing. Univariate Box - Jenkins ARIMA models and seasonal ARIMA models. Forecast models using plant characters, Agrometeorological models for crop forecasting, Markov chain models and ANN models.

Suggested Readings

Draper NR & Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.

Efromovich S. 1999. Nonparametric Curve Estimation. Springer.

Fan J & Yao Q. 2003. Nonlinear Time Series-Nonparametric and Parametric Methods. Springer.

France J & Thornley JHM. 1984. Mathematical Models in Agriculture. Butterworths.

Harvey AC. 1996. Forecasting, Structural Time Series Models and the Kalman Filter. Cambridge Univ. Press.

Makridakis, S., Wheelwright, S.C. and Hyndman, R.J. 1998. Forecasting: Methods and Applications. John Wiley.

Pankratz, A. 1983. Forecasting with Univariate Box Jenkins Models: Concepts and Cases. John Wiley.

Thornley J. & France J. (2006). Mathematical Models in Agriculture: Quantitative Methods for the Plant, Animal and Ecological Sciences (Cabi) 2nd Ed.

B. COMPUTER APPLICATIONS

C. M.Sc. Syllabus

MCA511 INTRODUCTION TO NETWORKING AND INTERNET APPLICATIONS (1+1)

Objectives

This is a course on Introduction to Networking and Internet Applications that aims at exposing the students to understand Computer networking and web applications development.

Theory

UNIT I

Networking fundamentals, types of networking, network topology; Introduction to File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP), Internet Protocol v4 & v6. Network infrastructure and Security-switches, routers, firewall, intranet, internet, Virtual Private Network

UNIT II

World Wide Web (WWW), working with Internet; Web pages, web sites, web servers; Web Applications.

UNIT III

Hyper Text Markup Language (HTML), DHTML, web based application development. Static websites, dynamic websites. Client Side processing – scripting languages, JQuery. Server Side processing ASP.NET/JSP

Practical

Network and mail configuration; Using Network Services; Browsing of Internet; Creation of web pages; Creation of websites using HTML and scripting languages.

Suggested Readings

Cox V, Wermers L & Reding EE. 2006. HTML Illustrated Complete. 3rd Ed. Course Technology.

Niederst J. 2001. Web Design in a Nutshell. O'Reilly Media.

Tanenbaum AS. 2003. Computer Networks. Prentice Hall of India.

Objectives

This is a course on Introduction to Networking and Internet Applications that aims at exposing the students to understand analogy of computer, basic knowledge of MS Office. Also to understand Internet and WWW, use of IT application and different IT tools in Agriculture

Theory**UNIT I**

Introduction to Computers, Anatomy of computer, Operating Systems, definition and types, Applications of MS Office for document creation & Editing, Data presentation, interpretation and graph creation, statistical analysis, mathematical expressions,

UNIT II

Database, concepts and types, uses of DBMS in Agriculture, World Wide Web (WWW): Concepts and components, Introduction to computer programming languages, concepts and standard input/output operations. e-Agriculture, concepts and applications,

UNIT III

Use of ICT in Agriculture, Computer Models for understanding plant processes. IT application for computation of water and nutrient requirement of crops, Computer-controlled devices (automated systems) for Agri-input management, Smartphone Apps in Agriculture for farm advises, market price, postharvest management etc.,

UNIT IV

Geospatial technology for generating valuable agri-information. Decision support systems, concepts, components and applications in Agriculture, Agriculture Expert System, Soil Information Systems etc. for supporting Farm decisions, Preparation of contingent crop-planning using IT tools.

Suggested Readings

Vanitha G (2011).Agro-informatics.

<http://www.agrimoon.com/> <http://www.agriinfo.in/> eagri.org

<http://www.agriglance.com/> <http://agritech.tnau.ac.in/>

Ph.D. Syllabus

MCA 601 SPATIAL INFORMATICS, GIS AND REMOTESENSING TECHNIQUES (1+1)

Objective

The basic objective of this course is to teach concepts of GIS and remote sensing with specific applications in agriculture related statistics.

Theory

UNIT I

Introduction to Geographical Information System (GIS); Introduction, maps and spatial information, components of a GIS; GIS Internals – data representation- raster and vector data structures and analysis techniques.

UNIT II

Digital Elevation Models; Data input, verification, storage and output.

UNIT III

Spatial modelling- manual and automatic digitizing process; Data errors in GIS; Classification methods- multivariate analysis and classification.

UNIT IV

Spatial interpolation; Current and potential uses of GIS in agricultural planning; Software components used in GIS; GIS in India.

UNIT V

Physics of remote sensing, atmospheric effects and remote sensing sensors; Spectral signatures of earth surface features, spectral characteristics of vegetation, soil and water.

UNIT VI

Data acquisition system, satellite image acquisition; Data collections: preprocessing and data storage; Visual and digital image interpretation; Digital image processing.

Practical

Digitization of a map with the help of a digitizer; Map editing; Georeferencing and map projections; Creation of attribute database and linking with spatial data; General analysis of the data with the help software; Applications of digital elevation models using GIS; Spatial interpolations using GIS; Visual interpretations of remote sensing data; Geometric corrections of remote sensing digital data; Methods for improving quality of digital data and Techniques of image classifications.

Suggested Readings

- Annadurai S & Shanmugalakshmi R. 2007. Fundamentals of Digital Image Processing. Pearson Edu.
Burrough PA. 1986. Principles of Geographic Information System for Land Resources Assessment. Oxford Univ. Press.
Curran PJ. 1985. Principles of Remote Sensing. Longman.
Jensen JR. 2017. Introductory Digital Image Processing. 4th Ed. Prentice Hall.
Lillesand TM & Kiefer RW. 1987. Remote Sensing and Image Interpretation. John Wiley.
Peuquet DJ & Marble DF. 1990. Introductory Readings in Geographic Information System. Taylor & Francis.

D. BIOCHEMISTRY

E. M.Sc.

Syllabus

BIOCHEM 501

BASIC BIOCHEMISTRY

(3+1)

Why this course?

To impart the fundamental knowledge on structure and function of cellular components involved in biological processes and an elementary introduction to the study of molecular biology.

Aim of the course

The course is designed to provide elementary knowledge/overview of structure and function of proteins, carbohydrates, lipids, nucleic acids and other biomolecules and their metabolism.

No.	Blocks	Units
1.	Introduction to Biochemistry	1. Scope and importance of biochemistry 2. Foundation of life 3. Water 4. Physical techniques for structure determination
2.	Structure and function of	1. Biomolecules biomolecules 2. Immunoglobulins and PR proteins 3. Plant secondary metabolites
3.	Metabolism – the basics	1. Molecules aiding metabolism 2. Thermodynamics –principles and energetic of life
4.	Catabolism and its regulation	1. Catabolism of energy molecules 2. ATP formation
5.	Fundamentals of Molecular biology	1. Molecular biology processes and genetic engineering 2. Recombinant DNA technology

Theory

Block 1: Introduction to Biochemistry

Unit 1: Scope and importance of biochemistry (1 Lecture): Biochemistry as modern science and its various divisions, Scope and importance of biochemistry in agriculture and allied sciences.

Unit 2: Foundation of life (2 Lectures): Fundamental principles governing life, supramolecular structures, significance of weak non covalent interactions in biology

Unit 3: Water (3 Lectures): Structure of water, ionization of water, acid base concept, pH and buffers, significance of structure-function relationship.

Unit 4: Physical techniques for structure determination (2 Lectures): General introduction to physical techniques for determination of structure of biopolymers.

Block 2: Structure And Function of Biomolecules

Unit 1: Biomolecules (10 Lectures): Structure, classification, properties and function of carbohydrates, amino acids, proteins, lipids and nucleic acids.

Unit 2: Immunoglobulins and PR proteins (2 Lectures): Structure, formation and different forms of immunoglobulins, PR proteins and their classification.

Unit 3: Plant secondary metabolites (3 Lectures): Structure, classification and function of plant secondary metabolites.

Block 3: Metabolism – The Basics

Unit 1: Molecules aiding metabolism (2 Lectures): Structure and biological functions of vitamins and coenzymes, enzymes: classification and mechanism of action; regulation, factors affecting enzyme action. Hormones: animal and plants.

Unit 2: Thermodynamics –principles and energetic of life (2 Lectures): Fundamentals of thermodynamic

principles applicable to biological processes, Bioenergetics.

Block 4: Catabolism and its Regulation

Unit 1: Catabolism of energy molecules (5 Lectures): Important and basic degradative metabolic pathways of carbohydrates, lipids and proteins and their regulation.

Unit 2: ATP formation (3 Lectures): Formation of ATP, substrate level phosphorylation, electron transport chain and oxidative phosphorylation, chemiosmotic theory and proton motive force.

Block 5: Fundamentals of Molecular Biology and Genetic Engineering

Unit 1: Molecular biology processes (4 Lectures): Overview of replication, transcription and translation.

Unit 2: Recombinant DNA technology (3 Lectures): Restriction enzymes, DNA cloning, applications of cloning, transgenics.

Practicals

- Preparation of standard and buffer solutions
- Detection of carbohydrates, amino acids and proteins
- Extraction and estimation of sugars
- Extraction and estimation of amino acids
- Extraction and estimation of proteins
- Estimation of acid value of fat/oil
- Estimation of peroxide value of fat/oil
- Estimation of saponification value in fats and oils
- Fatty acid composition in fat/oil by GC
- Estimation of DNA and RNA by spectroscopic methods
- Estimation of Ascorbic acid
- Separation of biomolecules by TLC and Paper chromatography
- Estimation of alpha amylase activity
- Qualitative tests for secondary plant metabolites.

Teaching methods/activities

- Classroom lectures (oral + audio-visual)
- Assignment (Reading/Writing)
- Oral presentation by students on specified topics
- Class room quiz

Learning outcome

With this course, the students are expected to be able to understand the actual chemical concepts and fundamental processes of biology at molecular level.

Suggested Reading

- Nelson DL and Cox MM. 2017. Lehninger Principles of Biochemistry. 7th edition. W. H. Freeman & Co Ltd
- Satyanarayana U and Chakrapani U. 2017. Biochemistry. 5th edition, Elsevier
- Moran LA, Horton HR, Scrimgeour KG and Perry MD. 2012. Principles of Biochemistry. 5th edition Pearson.
- Voet D and Voet JG. 2011. Biochemistry. 4th edition John Wiley.
- Pratt CW and Cornely K. 2014. Essential Biochemistry. 3rd Edition. Wiley
- Moorthy K. 2007. Fundamentals of Biochemical Calculations. 2nd edition. CRC Press
- Conn EE, Stumpf PK, Bruening G and Doi RH. 2006. Outlines of Biochemistry. 5th edition. Wiley.

Why this course?

Biochemical studies rely on the availability of appropriate analytical techniques and their applications. This course will examine modern methods and technologies that are used in biochemical analysis with emphasis on instrumentation, underlying principles, aims, strategies and current applications.

Aim of the course

To provide hands-on experience to different biochemical techniques commonly used in research along with the knowledge on principles and the instrumentation.

No.	Blocks	Units
1.	Separation techniques	1. Chromatography techniques 2. Electrophoretic technique 3. Hydrodynamic methods 4. Centrifugation
2.	Spectroscopic techniques	1. Spectrophotometry 2. Mass spectroscopy 3. Atomic absorption spectrophotometry
3.	Microscopy	1. Microscopic techniques
4.	Tracer, imaging, immunochemical	1. Tracer techniques and other techniques 2. Imaging techniques 3. Immunochemical techniques 4. Other techniques

Theory

Block 1: Separation Techniques: Principles and applications of separation techniques.

Unit 1: Chromatography techniques (4 Lectures): Principles and applications of paper, thin layer, gel filtration, ion-exchange, affinity, column & HPTLC, GC, HPLC and FPLC.

Unit 2: Electrophoretic technique (2 Lectures): General principles, paper and gel electrophoresis, native and SDS-PAGE, 2D-PAGE, capillary electrophoresis.

Unit 3: Hydrodynamic methods (2 Lectures): Hydrodynamic methods of separation of biomolecules such as viscosity and sedimentation velocity, - their principles.

Unit 4: Centrifugation (2 Lectures): Basic principles of sedimentation, type, care and safety aspects of centrifuge preparative and analytical centrifugation.

Block 2: Spectroscopic Techniques

Unit 1: Spectrophotometry (3 Lectures): Principles and applications of UV-visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy.

Unit 2: Mass spectroscopy (3 Lectures): MS/MS, LC-MS, GC-MS, MALDI-TOF, applications of mass spectrometry in biochemistry.

Unit 3: Atomic absorption spectrophotometry (2 Lectures): Principle, function and instrumentation of atomic absorption spectrophotometry.

Block 3. Microscopy

Unit 1: Microscopic techniques (2 Lectures): Principles and applications, light, UV, phase contrast, fluorescence and electron microscopy, flow cytometry.

Block 4: Tracer, Imaging, Immunochemical and Other Techniques

Unit 1: Tracer technique (2 Lectures): Tracer techniques in biology: concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of α , β and γ emitters, scintillation counters, x-ray spectrometers, autoradiography, applications of radioactive tracers in biology.

Unit 2: Imaging techniques (2 Lectures): Principles and applications of phosphor imager, MRI and CT scan.

Unit 3: Immunochemical technique (2 Lectures): Production of antibodies, immunoprecipitation, immunoblotting, immunoassays, RIA and ELISA.

Unit 4: Other techniques (2 Lectures): Cryopreservation, polymerase chain reaction (PCR), FACS.

Practicals

- Expression of concentration in terms of dilution, molarity, normality, percent expression
- pH measurement and buffer preparation
- Determination of absorption maxima of biomolecules
- Estimation of biomolecules through spectrophotometry and other methods
- Separation of carbohydrates and amino acids by paper chromatography
- Separation and analysis of fatty acids/lipids by GC
- Separation/estimation of biomolecules through HPLC and FPLC
- Separation of proteins using ion exchange, gel filtration and affinity chromatography
- Electrophoretic separation of proteins and nucleic acids
- Centrifugation- differential and density gradient
- (NH₄)₂SO₄ precipitation and dialysis
- Use of radioisotopes in metabolic studies
- PCR
- ELISA
- Western blotting/ Dot blotting

Teaching methods/activities

- Classroom lectures (oral + audio-visual)
- Assignment (Reading/Writing)
- Oral presentation by students on specified topics
- Class room quiz
- Case study

Learning outcome

At the end of the course, the student will acquire the basic knowledge of the main biochemical methods used in the separation, identification, characterization and analysis of biomolecules.

Suggested Reading

Boyer R. 2011. Biochemistry Laboratory: Modern Theory and Techniques 2nd Edition. Pearson

Hofmann A and Clokie S. 2010. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. 7th edition. Cambridge University Press.

Sawhney SK and Singh R. 2000. Introductory Practical Biochemistry. 2nd Ed. Narosa

Katoch R. 2011. Analytical Techniques in Biochemistry and Molecular Biology. Springer

Boyer R. 2009. Modern Experimental Biochemistry. Fifth impression. Pearson

Lottspeich F and Engels JW. (Eds). 2018. Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. Wiley-VCH

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

Why this course?

Harnessing sunlight, plants produce a diverse array of chemical compounds to survive in challenging ecological niches. Plant-derived metabolites are major sources of human food, fibre, fuel, and medicine. This course covers topics related to plant metabolism and discusses how plants generate carbon and energy sources by photosynthesis and synthesize various compounds through complex networks of metabolic pathways.

Aim of the course

To provide an understanding of metabolic processes in plants and the role of different biosynthetic pathways in plant growth and development.

S.No.	Blocks	Units
1	Photosynthesis	1. Photosynthetic machinery 2. Carbon reduction
2	Conversion of photosynthates	1. Synthesis of major biomolecules 2. Nitrogen and sulphur metabolism
3	Growth and development	1. Germination and fruit ripening 2. Phytohormones
	Secondary metabolites	1. Biochemistry of plant secondary metabolites

Theory**Block 1: Photosynthesis**

Unit 1: Photosynthetic machinery (3 Lectures): Structure and function of plant cell and its organelles, phytochromes, chloroplast morphology structure, structure and chemistry of photosynthetic pigments, light reaction of photosynthesis.

Unit 2: Photosynthesis – the process (4 Lectures): Carbon reduction in C₃, C₄ and CAM plants, photorespiration, sucrose-starch inter conversion.

Block 2: Conversion of Photosynthates

Unit 1: Synthesis of major biomolecules (3 Lectures): Biosynthesis of structural carbohydrates, storage proteins and lipids.

Unit 2: Nitrogen and sulphur metabolism (5 Lectures): Basic concepts of nitrogen and sulphur metabolism: biological nitrogen fixation, nitrate assimilation in plants, sulphur chemistry and function, reductive sulphate assimilation pathway, sulphated compounds.

Block 3: Growth and Development

Unit 1: Germination and fruit ripening (4 Lectures): Biochemistry of seed germination – stages, requirements, metabolism and mobilization of storage material; Biochemistry of fruit ripening – ripening process, cell wall degrading enzymes, role of ethylene and regulation of ethylene production.

Unit 2: Phytohormones (3 Lectures): Different classes of phytohormones, their biosynthesis and mode of action.

Block 4: Secondary Metabolites

Unit 1: Biochemistry of plant secondary metabolites (6 Lectures): Biochemistry and significance of plant secondary metabolites – phenolics, terpenoids, alkaloids, cyanogenic glycosides and glucosinolates, effect of biotic and abiotic factors on plant metabolism and plant defense system.

Practicals

- Fractionation of cell organelles,
- Estimation of starch,
- Assay of ADPG pyrophosphorylase/starch synthase,
- Assay of PAL/SOD

- Assay of PPO/LOX,
- Estimation of individual amino acids,
- Qualitative tests of secondary metabolites (alkaloids, sterols etc.)
- Content and composition of carotenoids, anthocyanin and chlorophylls
- Determination of polyphenols/phenolics
- Fractionation of storage proteins
- Estimation of glucosinolates
- Estimation of cyanogenic compounds.

Teaching methods/activities

- Classroom lectures (oral + audio-visual)
- Assignment (Reading/Writing)
- Oral presentation by students on specified topics
- Case study

Learning outcome

Successful completion of this course will provide students with fundamental knowledge of biochemistry and specific knowledge of compounds and biochemical pathways that occur in plants.

Resources

Buchanan BB, Gruissem W and Jones R.L. (eds.). 2000. Biochemistry and Molecular Biology of Plants. 2nd edition. WILEY Blackwell

Heldt, H-W. 2010. Plant Biochemistry and Molecular Biology. 4th ed. Oxford University Press

Goodwin TW and Mercer EI. 2005. Introduction to Plant Biochemistry. 2nd edition. CBS

Heldt, H-W. and Piechulla, B. 2010. Plant Biochemistry. 4th Edition. Elsevier

Harinda, Makke and Klaus. 2007. Plant Secondary Metabolites. Springer

Cseke LJ, Kirakosyan A, Kaufman PB, Warber S, Duke JA, Brielmann HL. 2006. Natural Products from Plants. 2nd Edition. CRC Press

Ph.D.

BIOCHEM 603

BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES

(3+0)

Why this course?

Plants are constantly confronted to both abiotic and biotic stresses that seriously reduce their productivity. Plant responses to these stresses involve numerous physiological, biochemical, molecular, and cellular adaptations. This course will help to have an insight into the mechanism underlying the stress tolerance and to elucidate the molecular basis of stress adaptation.

Aim of the course

To impart knowledge on biochemistry of biotic and abiotic stresses in plants.

S.No.	Blocks	Units
1	Biochemistry of biotic and abiotic stresses	1. Plant-pathogen interaction and disease development 2. Biochemistry of plant defence mechanisms 3. Plant host-virus interaction 4. Biochemical basis of abiotic stresses 5. Tolerance against biotic and abiotic stress

Theory

Block 1: Biochemistry of Biotic and Abiotic Stresses

Unit 1: Plant-pathogen interaction and disease development (4 Lectures): Molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.

Unit 2: Biochemistry of plant defence mechanisms (7 Lectures): Role of secondary metabolites, Plant defence response, antimicrobial molecules; genes for resistance, hypersensitive response and cell death; systemic and acquired resistance, pathogen derived resistance.

Unit 3: Plant host-virus interaction (4 Lectures): Plant viruses, host-virus interactions, disease induction, virus movement, and host range determination; viroids.

Unit 4: Biochemical basis of abiotic stresses (7 Lectures): Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants, synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation.

Unit 5: Tolerance against stress (6 Lectures): Reactive oxygen species and biotic and abiotic stress, antioxidants, enzymes of defense system. Role of calcium, nitric oxide and salicylic acid in plant development. Molecular strategies for imparting tolerance against biotic and abiotic stress.

Teaching methods/activities

- Classroom lectures (oral + audio-visual)
- Assignment (Reading/Writing)
- Oral presentation by students on specified topics
- Case study

Learning outcome

Upon completion of the course, students will get the suite of molecular and cellular processes that are triggered by plant stress responses.

Resources

Buchanan, Bob B., Gruisem, W. and Jones, R. 2015. Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley Blackwell.

Dresselhaus, T. and Hüchelhoven, R. (Eds.) 2019. Biotic and Abiotic Stress Responses in Crop Plants. MDPI. <https://doi.org/10.3390/agronomy8110267>

Rout, G.R. and Das, A.B. 2013. Molecular Stress Physiology of Plants. Springer. DOI 10.1007/978-81-322-0807-5

Shanker, A.K. and Shanker, C. (Eds.) 2016. Abiotic and Biotic Stress in Plants – Recent Advances and Future Perspectives. InTech. <http://dx.doi.org/10.5772/60477>

Ramakrishna, A. and Gill, S.S. 2018. Metabolic Adaptations in Plants During Abiotic Stress. CRC Press

Khan, M.I.R. and Khan, N.A. (Eds.). 2017. Reactive Oxygen Species and Antioxidant Systems in Plants: Role and Regulation under Abiotic Stress. Springer

Smirnoff, N. (ed.) 2005. Antioxidants and reactive oxygen species in plants, Blackwell

Why this course?

To update the students to the recent developments in various fields of biochemistry.

Aim of the Course

To acquaint the students with the advanced developments in the field of biochemistry and to inculcate the habit of searching and reading the topics of current importance.

S.No.	Blocks	Units
1	Frontier topics in Biochemistry	1. There will be 8 Units related to different areas in Biochemistry

Theory

Block 1: Frontier Topics in Biochemistry

Unit 1: Latest development in metabolic nutrition.

Unit 2: Latest development in environmental and industrial biochemistry.

Unit 3: Latest development in molecular biology techniques.

Unit 4: Latest development in metabolic engineering.

Unit 5: Latest development in regulation of gene expression.

Unit 6: Latest development in biotic and abiotic stress response in plants.

Unit 7: Latest development in protein chemistry.

Unit 8: Topics related to recent approaches concerning application of biochemical tools and techniques

Teaching methods/activities

- Oral presentation by students on specified topics based on recent published research paper
- Group discussion

Learning outcome

Students will build up the habit of searching and studying the topics of current importance and the recent developments in the field of biochemistry.

Suggested Reading

Selected articles from recent issues of Thomson Reuters and NAAS rated journals