# UNIVERSITY OF HORTICULTURAL SCIENCES, BAGALKOT

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No. R/UHSB/ AC-35/ 12022-23

Date: 20.03.2023

### NOTIFICATION

Sub	1	Course and Syllabus for Master's and Doctoral degree programmes as
		per the recommendations of the BSMA Committee from the academic
		year 2022-23 reg.

Ref :

- This office notification No.R/UHSB/Ac-34/Eligibility Criteria /285 /2022-23 dtd:18.06.2022
- 2. Corrigendum No. R/UHSB/AC-34/BSMA/430/2022-23, dt.20.07.2022
- Minutes on Item No: 03 of 35<sup>th</sup> Academic Council meeting held on 10.01.2023
- 4. This office e-mail dtd 27.02.2023 and 09.03.2023
- E-mail received from the Dean(PGS), UHS, Bagalkot dtd:17.03.2023
- 6. Recommendation of the Dean (PGS), UHS, Bagalkot
- 7. Approval of the Director of Education, UHS, Bagalkot
- 8. Orders of the Hon'ble Vice Chancellor, UHS, Bagalkot

In pursuance of the above references, the Department names, Course names, Symbols, credit hours, course structure for Master's and Doctoral degree programmes are notified as per the above notification/Corrigendum (Ref 1 & 2). Further, as per the recommendations of the BSMA Committee and decision of the Academic Council (Ref 3) the **"Course and Syllabus for Master's and Doctoral degree programmes 2022-23"** are hereby notified as enclosed in Annexure I & II respectively. These Course and Syllabus are applicable from the academic year 2022-23 and onwards.

By Order, REGISTRAR UHS, BAGALKOT.

Enclosure: Annexure | & ||

To: 1. All the members of the Academic Council

- 2. All the Deans of UHS, Bagalkot
- 3. The Director, SC/ST cell, UHS, Bagalkot
- 4. The Controller of Examination, CEEU, UHS, Bagalkot
- 5. All Academic Units/ Account Sections of UHS, Bagalkot

6. The Personal Secretary to the Hon'ble Vice-Chancellor, UHS, Bagalkot

7. Notice Board- Concerned Colleges, UHS, Bagalkot

**Copy to:** The University Librarian, UHS, Bagalkot with a request to upload the same in the University website

Copy submitted for kind information to: The Director of Education, UHS, Bagalkot



# UNIVERSITY OF HORTICULTURAL SCIENCES BAGALKOT

# COURSE SYLLABUS FOR MASTER DEGREE PROGRAMME (Revised Syllabus as per BSMA)

SEMESTER SYSTEM

2022-23 OFFICE THE DEAN POSTGRADUATE STUDIES UNIVERSITY OF HORTICULTURAL SCIENCES BAGALKOT - 587 104



# UNIVERSITY OF HORTICULTURAL SCIENCES BAGALKOT POSTGRADUATE PROGRAMMES

# **Masters Degree Programme**

Year of Publication	:	2023
No. of Copies	:	500
Edited & updated by	:	Dean Post Graduate Studies UHS, Bagalkot

Published by	:	Vice-Chancellor		
		UHS, Bagalkot- 587 104		

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Course No.	Course Title	Credit Hours
PGS 501	Library and Information Services	0+1
PGS 502	Technical Writing and Communications Skills	0+1
PGS 503	Intellectual Property and its Management in Agriculture	1+0
PGS 504	Basic Concepts in Laboratory Techniques	0+1
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0

### **COMMON COMPULSORY COURSES**

### PGS 501 Library and Information Services

0+1

### Practicals

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

### **Suggested References**

- Rajkumar Singh, 2014, Handbook of Library and Information Services (For Agriculture Science Students), Publisher-Daya Publishing House, Arunachal Pradesh.
- Dr. Badan Barman, 2022, A Comprehensive Book on Library and Information Science, Publisher-LIS Links, Guwahati.

PGS 502Technical Writing and Communications Skills0-	0+1
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### Practicals

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
- Writing of abstracts, summaries, précis, citations, etc.;
- Commonly used abbreviations in the theses and research communications;
- Illustrations, photographs and drawings with suitable captions; pagination,
- numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading;
- Writing of a review article;
- Communication Skills Grammar (Tenses, parts of speech, clauses, punctuation marks);

- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- Accentual pattern: Weak forms in connected speech;
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

### **Suggested References**

Barnes and Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India. Collins' Cobuild English Dictionary. 1995.
Harper Collins. Gordon HM and Walter JA. 1970. Technical Writing. 3rd Ed.
Holt, Rinehart and Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
James HS. 1994. Handbook for Technical Writing. NTC Business Books.
Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
Mohan K. 2005. Speaking English Effectively. MacMillan India.
Richard WS. 1969. Technical Writing.
Sethi J and Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
Wren PC and Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

DCS 502	Intellectual Property and its Management in Agriculture	1.0
PGS 503	Intellectual Property and its Management in Agriculture	1+0

### 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.

- Erbisch FH and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
- Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
- Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.
- Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.

- 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	<b>Basic Concepts in Laboratory Techniques</b>	0+1
PGS 504	<b>Basic Concepts in Laboratory Techniques</b>	0+

### Practicals

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

### **Suggested Referencess**

Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press. Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

PGS 505	Agricultural	Research,	Research	Ethics	and	Rural	Development	1+0
	Programmes							

### 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.

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

### SUPPORTING COMPULSORY COURSES

Course No.	Course Title	Credit Hours
BCM 501	Basic Biochemistry	2+1
HST 502	Experimental Designs	2+1

BCM 501	Basic Biochemistry	2+1

### Theory

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; Structure of water; Acid–base concept and buffers; pH; Hydrogen bonding; Hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers. Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids. Structure and biological functions of vitamins; Enzymes: classification and mechanism of action, regulation, factors affecting enzyme action. Hormones: animals, plants and insects.Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics. Metabolism of carbohydrates, photosynthesis and respiration, oxidative phosphorylation, lipids, proteins and nucleic acids. DNA replication, transcription and translation; recombinant DNA technology.

### **Practicals**

Preparation of standard and buffer solutions, Extraction and estimation of sugars, Amino acids, Estimation of Proteins by Lowry's method, Estimation of DNA and RNA by diphenylamine and orcinol methods. Estimation of Ascorbic acid. Separation of biomolecules by TLC and Paper chromatography.

- 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. 5<sup>th</sup> 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.

HST 502	Experimental Designs	2+1
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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.

### **Practicals**

- 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 References**

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

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

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

Federer WT. 1985. Experimental Designs. MacMillan.

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

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

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

FRUIT	SCIENCE
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Sl. No.	Course No.	Course Title	Credit Hours
Major co	ourses (Minimu	um 20 Credits)	
1	FSC 501*	Tropical Fruit Production	2+1
2	FSC 502*	Sub-Tropical and Temperate Fruit Production	2+1
3	FSC 503*	Propagation and Nursery Management of Fruit Crops	2+1
4	FSC 504*	Breeding of Fruit Crops	2+1
5	FSC 505	Systematics of Fruit Crops	2+1
6	FSC 506	Canopy Management in Fruit Crops	1+1
7	FSC 507	Growth and Development of Fruit Crops	2+1
8	FSC 508	Nutrition of Fruit Crops	2+1
9	FSC 509	Biotechnology of Fruit Crops	2+1
10	FSC 510	Organic Fruit Culture	2+1
11	FSC 511	Export Oriented Fruit Production	2+1
12	FSC 512	Climate Change and Fruit Crops	1+0
13	FSC 513	Minor Fruit Production	2+1
14	FSC 514	Principles and Practices of Dry Land Horticulture	1+1
15	FSC 515	Orchard Management	1+1
16	FSC 516	Principles and Practices of Water Management in Horticultural Crops	1+1
17	FSC 517	Bio-diversity and Conservation of Fruit Crops	2+1
18	FSC 518	Plant Growth Regulators in Fruit Crops	1+1
19	FSC 519	GAP for Horticultural Crops	1+0
20	FSC 571	Qualifying Examination	0+2
21	FSC 581	Seminar-I	0+1
22	FSC 582	Seminar-II	0+1
23	FSC 591	Research	0+27

\* Compulsory among major courses

Block 1: Introduction

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

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

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, Annonas, Aonla, etc. Sapota, Jamun, Tamarind, Mangosteen, Carambola, Bilimbi.

### **Practicals**

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

- Bartholomew DP, Paull RE and Rohrbach KG. 2002. *The Pineapple: Botany, Production, and Uses.* CAB International.
- Bose TK, Mitra SK and Sanyal D. 2002. Fruits of India Tropical and Sub-Tropical.3rd Edn. Naya Udyog, Kolkata.
- Dhillon WS. 2013. Fruit Production in India. Narendra Publ. House, New Delhi.
- Iyer CPA and Kurian RM. 2006. *High Density Planting in Tropical Fruits: Principlesand Practices*. IBDC Publishers, New Delhi.
- Litz RE. 2009. *The Mango: Botany, Production and Uses*. CAB International. Madhawa Rao VN. 2013. *Banana*. ICAR, New Delhi.
- Midmore D. 2015. *Principles of Tropical Horticulture*. CAB International. Mitra SK and Sanyal D. 2013. *Guava*, ICAR, New Delhi.
- Morton JF. 2013. *Fruits of Warm Climates*. Echo Point Book Media, USA. Nakasome HY and Paull RE. 1998. *Tropical Fruits*. CAB International. Paull RE and Duarte O. 2011. *Tropical Fruits* (Vol. 1). CAB International.

- Rani S, Sharma A and Wali VK. 2018. *Guava (Psidium guajava* L.). Astral, New Delhi. Robinson JC and Saúco VG. 2010. *Bananas and Plantains*. CAB International.
- Sandhu S and Gill BS. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi. Schaffer B, Wolstenholme BN and Whiley AW. 2013. *The Avocado: Botany, Production and Uses*. CAB International.
- Sharma KK and Singh NP. 2011. Soil and Orchard Management. Daya Publishing House, New Delhi.

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

FSC 502	Subtropical and Temperate Fruit Production	2+1
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### Theory

- Block 1: Introduction
- Unit I: Importance and Background: Origin, distribution and importance, major species, rootstocks and commercial varieties of regional, national and international importance, eco-physiological requirements.
- Block 2: Agro-Techniques
- Unit I: Propagation, Planting and Orchard Floor Management: Propagation, planting systems and densities, training and pruning, rejuvenation and replanting, intercropping, nutrient management, water management, fertigation, use of bio-fertilizers, role of bio-regulators, abiotic factors limiting fruit production.
- Block 3: Crop Management
- Unit I: Flowering, Fruit-Set and Harvesting: Physiology of flowering, pollination management, fruit set and development, physiological disorders- causes and remedies, crop regulation, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; insect and disease management.
- Crops

Citrus, Grapes, Litchi, Pomegranate, Apple, Pear, Peach, Plum, Apricot, Cherries, Berries, Persimmon, Kiwifruit, Nuts- Walnut, Almond, Pecan, ber, aonla, date palm

### Practicals

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

### Suggested References

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

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

- Creasy G and Creasy L. 2018. *Grapes.* CAB International. Davies FS and Albrigo LG. 1994. *Citrus.* CAB International.
- Dhillon WS. 2013. Fruit Production in India. Narendra Publishing House, New Delhi. Jackson D, Thiele G, Looney NE and Morley-Bunker M. 2011. Temperate and Subtropical
- Fruit Production. CAB International.
- Ladanyia M. 2010. *Citrus Fruit: Biology, Technology and Evaluation*. Academic Press. Layne DR and Bassi D. 2008. *The Peach: Botany, Production and Uses*. CABI.
- Menzel CM and Waite GK. 2005. *Litchi and Longan: Botany, Production and Uses*. CAB International.
- Pandey RM and Randey SN. 1996. The Grape in India. ICAR, New Delhi.
- Rajput CBS, and Haribabu RS. 2006. *Citriculture*, Kalyani Publishers, New Delhi. Sandhu S and Gill BS. 2013. *Physiological Disorders of Fruit Crops*. NIPA, New Delhi.
- Sharma RM, Pandey SN and Pandey V. 2015. *The Pear Production, Post-harvest Management and Protection*. IBDC Publisher, New Delhi.
- Sharma RR and Krishna H. 2018. *Textbook of Temperate Fruits*. CBS Publishers and Distributors Pvt. Ltd., New Delhi.
- Singh S, Shivshankar VJ, Srivastava AK and Singh IP. 2004. *Advances in Citriculture*. NIPA, New Delhi.
- Tromp J, Webster AS and Wertheim SJ. 2005. *Fundamentals of Temperate Zone Tree Fruit Production*. Backhuys Publishers, Lieden, The Netherlands.
- Webster A and Looney N. Cherries: Crop Physiology, Production and Uses. CABI.
- Westwood MN. 2009. Temperate Zone Pomology: Physiology and Culture. Timber Press, USA.

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

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

- Bose TK, Mitra SK and Sadhu MK. 1991. Propagation of Tropical and Subtropical Horticultural Crops. Naya Prokash, Kolkatta.
- Davies FT, Geneve RL and Wilson SB. 2018. Hartmann and Kester's Plant Propagation- Principles and Practices. Pearson, USA/ PrenticeHall of India. New Delhi.
- Gill SS, Bal JS and Sandhu AS. 2016. *Raising Fruit Nursery*. Kalyani Publishers, New Delhi. Jain S and Ishil K. 2003. *Micropropagation of Woody Trees and Fruits*. Springer.

- Jain S and Hoggmann H. 2007. Protocols for Micropropagation of Woody Trees and Fruits. Springer.
- Joshi P. 2015. Nursery Management of Fruit Crops in India. NIPA, New Delhi.
- Love *et al.* 2017. *Tropical Fruit Tree Propagation Guide*. UH-CTAHR F\_N\_49. College of Tropical Agriculture and Human Resources University of Hawaii at Manwa, USA.
- Peter KV, eds. 2008. *Basics of Horticulture*. New India Publishing Agency, New Delhi. Rajan S and Baby LM. 2007. *Propagation of Horticultural Crops*. NIPA, New Delhi.
- Sharma RR. 2014. Propagation of Horticultural Crops. Kalyani Publishers, New Delhi. Sharma RR and Srivastav M. 2004. Propagation and Nursery Management. Intl. Book Publishing Co., Lucknow.
- Singh SP. 1989. Mist Propagation. Metropolitan Book Co.
- Singh RS. 2014. Propagation of Horticultural Plants: Arid and Semi-Arid Regions. NIPA, New Delhi.
- Tyagi S. 2019. *Hi-Tech Horticulture*. Vol I: Crop Improvement, Nursery and Rootstock Management. NIPA, New Delhi.

FSC 504	Breeding of Fruit Crops	2+1
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Block 1: Introduction

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

Block 2: Reproductive Biology

- Unit I: Blossom Biology and Breeding Systems: Blossom biology, breeding systems spontaneous mutations, polyploidy, incompatibility, sterility, parthenocarpy, apomixis, breeding objectives, ideotypes.
- Block 3: Breeding Approaches
- Unit I: Conventional and Non-Conventional Breeding: Approaches for crop improvement direct introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrusts.

Crops

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

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

### **Suggested References**

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

- Badenes ML and Byrne DH. 2012. *Fruit Breeding*. Springer Science, New York. Dinesh MR. 2015. *Fruit Breeding*, New India Publishing Agency, New Delhi.
- Ghosh SN, Verma MK and Thakur A. 2018. *Temperate Fruit Crop Breeding-Domestication to Cultivar Development*. NIPA, New Delhi.
- Hancock JF. 2008. Temperate Fruit Crop Breeding: Germplasm to Genomics. Springer Science, New York.
- Jain SN and Priyadarshan PM. 2009. *Breeding Plantation and Tree Crops: Tropical Species*.Springer Science, New York.
- Jain S and Priyadarshan PM. 2009. *Breeding Plantation and Tree Crops: Temperate Species*.Springer Science, New York.
- Janick J and Moore JN. 1996. Fruit Breeding. Vols. I–III. John Wiley & Sons, USA.
  Kumar N. 2014. Breeding of Horticultural Crops:Principles and Practices.
  NIPA, N. Delhi. Moore JN and Janick J. 1983. Methods in Fruit Breeding.
  Purdue University Press, USA. Ray PK. 2002. Breeding Tropical and Subtropical Fruits. Narosa Publ. House, New Delhi.

FSC 505	Systematics of Fruit Crops	2+1
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### Theory

Block 1: Biosystematics

- Unit I: Nomenclature and Classification: Biosystematics introduction and significance; history of nomenclature of cultivated plants, classification and nomenclature systems; International code of nomenclature for cultivated plants
- Unit I: Identification and Description: Methods of identification and description of cultivated fruit and nut species and their wild relatives features; development of plant keys for systematic identification and classification. Development of fruit crop descriptors- based upon Bioversity International Descriptors and UPOV/ DUS test guidelines, botanical and pomological description of major cultivars and rootstocks of tropical, subtropical and temperate fruits and nut crops content changed

Block 3: Special Topics

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

### Practicals

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

### Suggested References

- ASHS. 1997. The Brooks and Olmo Register of Fruit and NutVarieties. 3rd Ed. ASHS Press. Bhattacharya B and Johri BM. 2004. Flowering Plants: Taxonomy and Phylogeny. Narosa Pub.House, New Delhi.
- Pandey BP. 1999. Taxonomy of Angiosperms. S. Chand & Co. New Delhi.
- Pareek OP and Sharma S. 2017. Systematic Pomology. Scientific Publishers, Jodhpur. Sharma G, Sharma OC and Thakur BS. 2009. Systematics of Fruit Crops. NIPA, New Delhi. Simpson M. 2010. Plant Systematics. 2ndEdn. Elsevier.
- Spencer RR, Cross R and Lumley P. 2003. *Plant Names*. 3rd Ed. A *Guide to Botanical Nomenclature*, CISRO, Australia.
- Srivastava U, Mahajan RK, Gangopadyay KK, Singh M and Dhillon BS. 2001. *Minimal Descriptors of Agri-Horticultural Crops. I: Fruits.* NBPGR, New Delhi.

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



### 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

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

### **Suggested References**

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

- Chadha KL and Shikhamany SD. 1999. *The Grape, Improvement, Production and Post Harvest Management*. Malhotra Publishing House, Delhi.
- Iyer CPA and Kurian RM. 2006. *High Density Planting in Tropical Fruits: Principles and Practices.* IBDC Publishers, New Delhi.

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

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

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

Block 1: Introduction

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

**Block 2:** Environment and Development

Unit I: Climatic Factors, Hormones and Developmental Physiology: Environmental impact on growth and development- effect of light, temperature, photosynthesis and photoperiodism, vernalisation, heat units and thermoperiodism. Assimilate partitioning, influence of water and mineral nutrition in growth and development; concepts of plant hormone and bioregulators, history, biosynthesis and physiological role of auxins, gibberellins, cytokinins, abscissic acid, ethylene, growth

inhibitors and retardant, brasssinosteroids, other New PGRs. Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development.

### **Block 3:** Stress Management

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

### **Practicals**

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

- Bhatnagar P. 2017. Physiology of Growth and Development of Horticultural Crops. Agrobios (India).
- Buchanan B, Gruiessam W and Jones R. 2002. Biochemistry and Molecular Biology of Plants. John Wiley & Sons, NY, USA.
- Dhillon WS and Bhatt ZA. 2011. Fruit Tree Physiology. Narendra Publishing House, New Delhi. Durner E. 2013. Principles of Horticultural Physiology. CAB International.NY, USA.
- Faust M. 1989. Physiology of Temperate Zone Fruit Trees. John Willey & Sons, NY, USA. Fosket DE. 1994. Plant Growth and Development: a Molecular Approach. Academic Press, USA. Leopold AC and Kriedermann PE. 1985. Plant Growth and Development. 3rd Ed. McGraw-Hill, New Delhi.
- Roberts J, Downs S and Parker P. 2002. Plant Growth Development. In: Salisbury FB and Ross CW. (Eds.) Plant Physiology. 4th Ed.Wadsworth Publications, USA.

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

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

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### 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 macroand 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

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

### Suggested References

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

Heinemann.

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

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

Epstein E. 1972. *Mineral Nutrition of Plants: Principles and Perspectives*. Wiley Eastern Ltd.

Kanwar JS. 1976. Soil Fertility-Theory and Practice. ICAR, New Delhi.

- Marchner Horst. 1995. *Mineral Nutrition of Higher Plants*, 2nd Ed. Marschner, Academic Press Inc. San Diego, CA.
- Mengel K and Kirkby EA. 1987. *Principles of Plant Nutrition*. 4th Ed. International Potash Institute, Worblaufen-Bern, Switzerland.
- Prakash M. 2013. Nutritional Disorders in Fruit Crops: Diagnosis and Management. NIPA, New Delhi.

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

- Westerman RL. 1990. *Soil Testing and Plant Analysis*, 3rd Ed. Soil Science Society of America, Inc., Madison, WI.
- Yawalkar KS, Agarwal JP and Bokde S. 1972. *Manures and Fertilizers*. 3rd Ed. Agri Horticultural Publishing House, Nagpur.

FSC 509	<b>Biotechnology of Fruit Crops</b>	2+1

### Theory

Block 1: General Background

Unit I: Introduction, History and Basic Principles: Introduction and significance,

history and basic principles, influence of explant material, physical,

chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture.

Block 2: Tissue Culture

Unit I: *In-vitro* Culture and Hardening: Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis; Organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture. Use of bioreactors and *in-vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues. Hardening and *ex vitro* establishment of tissue cultured plants.

Block 3: Genetic Manipulation

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

### Practicals

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

- Bajaj YPS. Eds., 1989. Biotechnology in Agriculture and Forestry. Vol. V, Fruits. Springer, USA.
- Brown TA. 2001. *Gene Cloning and DNA Analysis and Introduction*. Blackwell Publishing, USA.
- Chahal GS and Gosal SS. 2010. Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches. Narosa, New Delhi.

- Chopra VL and Nasim A. 1990. Genetic Engineering and Biotechnology Concepts, Methods and Applications. Oxford & IBH, New Delhi.
- Kale C. 2013. Genome Mapping and Molecular Breeding in Plant, Vol 4. *Fruit and Nuts*. Springers.
- Keshavachandran R and Peter KV. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer*. Orient & Longman, Universal Press, US.
- Keshavachandran R, Nazeem PA, Girija D, John PS and Peter KV. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. Vols. I, II. NIPA, New Delhi.
- Litz RE. 2005. Biotechnology of Fruit and Nut Crops. CABI, UK.
- Miglani GS. 2016. Genetic Engineering Principles, Procedures and Consequences. Narosa Publishing House, New Delhi.
- Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK and Mohanadas S. 2001. *Biotechnology of Horticultural Crops*. Vols. I–III. Naya Prokash, Kolkata.
- Peter KV. 2013. Biotechnology in Horticulture: Methods and Applications. NIPA, New Delhi. Vasil TK, Vasi M, While DNR and Bery HR. 1979. Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture. Platinum Press, UK.

FSC 510	Organic Fruit Culture	2+1

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; onfarm 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

### Practicals

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.

• Design of organic orchards/ farms management (1);

- Conversion plan (1);
- Nutrient management and microbial assessment of composts and bio-enhancers (2);
- Preparation and application of composts, bio-enhancers and bio-pesticides (2);
- Organic nursery raising (1);
- Application of composts, bio-enhancers, bio-fertilisers and bio-pesticides, green manure, cover, mulching (2);
- Preparation and use of neem based products (1);
- Biodynamic preparations and their role in organic agriculture, EM technology and products, biological/ natural management of pests and diseases (2);
- Soil solarisation (1);
- Frame work for GAP (1);
- Documentation for certification (1)

- Claude A. 2004. *The Organic Farming Sourcebook*. Other India Press, Mapusa, Goa, India. Dabholkar SA. 2001. *Plenty for All*. Mehta Publishing House, Pune, Maharashtra.
- Das HC and Yadav AK. 2018. Advances in Organic Production of Fruit Crops. Westville Publishing House, New Delhi.
- Deshpande MS. 2003. Organic Farming with respect to Cosmic Farming. Mrs. Pushpa Mohan Deshpandey, Kolhapur, Maharashtra.
- Deshpande WR. 2009. *Basics of Organic Farming*. All India Biodynamic and Organic Farming Association, Indore. MP.
- Gaur AC, Neblakantan S and Dargan KS. 1984 Organic Manures. ICAR, New Delhi. Lampkin, N. and Ipswich, S. 1990. Organic Farming. Farming Press. London, UK.
- Lind K, Lafer G, Schloffer K, Innershofer G and Meister H. 2003. Organic Fruit Growing. CAB International.
- Palaniappan SP and Annadurai K. 2008. Organic Farming- Theory and Practice. Scientific Publishers, Jodhpur, Rajasthan, India.
- Palekar S. 2004. *The Technique of Spritual Farming*. Chandra Smaritee, Sai Nagar, Amrawati, Maharashtra.
- Proctor P. 2008. Biodynamic Farming and Gardening. Other India Press, Mapusa, Goa. Ram RA and Pathak RK. 2017. Bioenhancers. Lap Lambert Academic Publishing, AP.

FSC 511	Export Oriented Fruit Production	2+1
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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

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

### Suggested References

- Chadha KL. 1995. Advances in Horticulture. Vol. XII. Malhotra Publ. House, New Delhi.
- Chetan GF. 2015. Export Prospects of Fruits and Vegetables from India: A study of Export market in EU. A project report. Anand Agricultural University, Anand, Gujarat.
- Dattatreylul M. 1997. Export potential of Fruits, Vegetables and Flowers from India. NABARD, Mumbai.
- Islam, C.N. 1990. Horticultural Export of Developing Countries: Past Preferences, Future Prospects and Policies. International Institute of Food Policy Research, USA.

e-Resources http://apeda.gov.in http://nhb.gov.in http://indiastat.com

FSC 512   Climate Change and Fruit Crops   1+0	FSC 512	Climate Change and Fruit Crops	1+0	1
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Block 1: General Aspects

- Unit I: Introduction, Global Warming and Climatic Variability: Introduction to climate change. Factors directly affecting climate change. Global warming, effect of climate change on spatio-temporal patterns of temperature and rainfall, concentrations of greenhouse gasses in atmosphere. pollution levels such as tropospheric ozone, change in climatic variability and extreme events.
- Block 2:
- Unit I: Impact Assessment and Mitigation: Sensors for recording climatic parameters, plants response to the climate changes, premature bloom, marginally overwintering or inadequate winter chilling hours, longer growing seasons and shifts in plant hardiness for fruit crops. Climate mitigation measures through crop management- use of tolerant rootstocks and varieties, mulching use of plastic-windbreak- spectral changes- protection from frost and heat waves. Climate management in greenhouse- heating vents CO<sub>2</sub> 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.

### **Suggested References**

- Dhillon WS and Aulakh PS. 2011. *Impact of Climate Change in Fruit Production*. Narendra Publishing House, New Delhi.
- Peter KV. 2008. Basics in Horticulture. New India Publishing Agency, New Delhi.
- Ramirez F and Kallarackal J. 2015. *Responses of Fruit Trees to Global Climate Change*. Spinger- Verlag.
- Rao GSLHV. 2008. Agricultural Meteorology. Prentice Hall, New Delhi.
- Rao GSLHV, Rao GGSN, Rao VUM and Ramakrishnan YS. 2008. *Climate Change and Agriculture over India*. ICAR, New Delhi.
- Schafeer B and Anderson P. 1994. *Handbook of Environmental Physiology of Fruit Crops*.Vol.1 & 2. CRC Press. USA.

### Theory

- Block 1: Introduction
- Unit I: Occurrence, Adoption and General Account: Importance occurrence and distribution, climate adaptation in fragile ecosystem and wastelands.
- Block 2: Agro-Techniques

- Unit I: Propagation and Cultural Practices: Traditional cultural practices and recent development in agro-techniques; propagation, botany-floral biology, growth patterns, mode of pollination, fruit set, ripening, fruit quality.
- Block 3: Marketing and Utilization
- Unit I: Post-Harvest Management: Post harvest management, marketing; minor fruit crops in terms of medicinal and antioxidant values; their uses for edible purpose and in processing industry

Crops

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

### **Practicals**

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

### **Suggested References**

Ghosh SN, Singh A and Thakur A. 2017. Underutilized Fruit Crops: Importance and Cultivation.

Jaya Publication House, New Delhi.

Krishna H and Sharma RR, 2017. Fruit Production: Minor Fruits. Daya Publishing House, New Delhi.

### Theory

Definition, importance and limitation of dry land horticulture, present status and future scope. Constraints encountered in dry lands. Agro-climatic features in rain shadow areas, scarce water resources, high temperature, soil erosion, run-off losses etc. Techniques and management of dry land horticulture. Watershed development, soil and water conservation methods – terraces, contour bunds, etc. Methods of control and impounding of run-off water – farm ponds, trenches, macro catch pits, etc., in-situ water harvesting methods, micro catchment, different types of tree basins etc. Methods of reducing evapotranspiration, use of shelter belts, mulches, antitranspirants, growth regulators, etc. Water use efficiency – need based, economic and conjunctive use of water, micro systems of irrigation etc. Selection of plants having drought resistance.

Special techniques, planting and after care – use of seedling races, root stocks, in–situ grafting, deep pitting f planting, canopy management etc.

### **Practicals**

Study of rainfall patterns. Contour bunding*f* trenching, micro catchments, soil erosion and its control. Study of evapotranspiration, mulches and micro irrigation systems. Special techniques of planting and aftercare in dry lands. Study of morphological and anatomical features of drought tolerant fruit crops.

### **Suggested References**

Chadha, K.L. and O.P. Pareek (Ed). 1993 Advances in Horticulture, vols. I-Iv. Fruits, Malhotra Publishing House, New Delhi.



### Theory

Definition of orchards, Importance and scope of orchard management, types of orchards, Planning, design and layout of orchards. Selection of crops, varieties and procurement of quality planting material. Establishment of orchards, Soil management practices, Cropping systems in tropical, sub– tropical, temperate and silvi–horticultural plants, multistoried cropping system.Soil and water conservation practices in fruit orchards. Management of problematic soils. water, nutrient and weed management. Training, pruning and management of bearing orchard. Mechanisation in orchard, Harvesting, disposal and marketing of orchard produce, book keeping and accounting.

### **Practicals**

Planning, layout and design of different orchards, planting systems. Study of different soil management practices, in-situ moisture conservation. Study of irrigation system including design and layout.weed management, Estimation of cost of cultivation of fruit production. Records and maintenance of records. Visit to progressive fruit orchard.

### **Suggested References**

Arakeri, H.R. and L. Donahue roy, 1984. Principles of Soil conservation and Water Management . Oxford and IBH Publishing co, New Delhi.

### Theory

Water and its role in plants, Importance of irrigation, water resources and their utilization, water requirement of the fruit crops, soil– plant–water relationships,Soil water movement, soil moisture stress and excess in relation to growth and productivity of fruit crops. Soil moisture extraction pattern, moisture contents and conservation methods. Determination of irrigation needs in relation to physiological stages of plant development, need based irrigation. Irrigation in rainfed orchards. effects of excess water–salinity problems etc. Quality and measurements of irrigation water. Sources and distribution pattern of irrigation water. Estimation of water requirement of different fruit

crops. Consumptive and water use efficiency, quantity and frequency of irrigation. Methods of irrigation and layout of different systems. Micro systems of irrigation. Fertigation, Water management in controlled environment.

#### **Practicals**

Study of water requirements of different crops and designing cropping pattern in relation to water requirements. Measurement of Soil moisture, Methods of irrigation, Planning, Layout and installation of drip irrigation system, drainage systems.

### **Suggested References**

Chadha, K.L.and O.P. Pareek (Ed). Advances in Horticulture. Vol.2 Malhotra Publishing House, New Delhi.

FSC 517	Bio-diversity and Conservation of Fruit Crops	2+1
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#### Theory

Biodiversity and conservation; issues and goals, centers of origin of cultivated fruits; primary and secondary centers of genetic diversity. Present status of gene centers; exploration and collection of germplasm; conservation of genetic resources – conservation in situ and ex situ. Germplasm conservation– problem of recalcitrancy – cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine.Intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group. GIS and documentation of local biodiversity, Geographical indication. Crops covered Mango, sapota, citrus, guava, banana, papaya, grapes, jackfruit, custard apple, ber, aonla, apple, litchi.

#### Practicals

Documentation of germplasm – maintenance of passport data and other records of accessions; field exploration trips, exercise on ex situ conservation – cold storage, pollen f seed storage, cryopreservation, visits to National Gene Bank and other centers of PGR activities.

#### **Suggested References**

Frankel,O.H. and J.G. Hawkes, 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press. U.K.

<b>FSC 518</b>	Plant Growth Regulators in Fruit Crops	1+1
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### Theory

History, nomenclature, role and physiological effects of auxins, gibberllins, cytokinins, inhibitors and growth retardant. Methods of application of growth regulators. Factors influencing absorption, translocation, degradation. Use of growth regulators in plant propagation, seed and bud dormancy, apical dominance, flower bud initiation, regulation of flowering, flower and fruit thinning, fruitset and fruit development, fruit drop and parthenocarpy, fruit ripening and quality improvement in fruit and plantation crops, viz., Mango, citrus, grapes, banana, pineapple, Pomegranate, litchi.

#### Practicals

Preparation of growth regulator solutions and other commercially available formulation. Application in plant propagation, prevention of flower and fruit drop, induction of parthenocarpy, fruitset, fruit thinning and fruit ripening and quality improvement.

### **Suggested References**

Leopold, L.C. and P.E. Kriedemann 1998, Plant Growth and Development Tata Mc Graw Hill Publishing Company, New Delhi.

FSC 519	GAP for Horticultural Crops	1+0
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### Theory

Genesis of GAP – definition*f* description, components listed by FAO, frame work. Management of site history and soil, crop and fodder production, IPM, INM, IWM, irrigation water, crop production and protection. Identification of ways of improving the productivity, profitability, and resource efficiency, harvest and post–harvest handling. Animal production, product certification, animal waste management, animal health and welfare, harvest. On farm processing, storage, energy and waste management, human health, welfare, safety, wild life benefits. Institutions involved in GAP certification. Indian agencies, EUREPGAP (European Retail Producers Group– Good Agricultural Practices), EUREP etc.

Sl.No.	Course	Course Title	Credit
	No.		Hours
Major	courses (Mini	imum 20 Credits)	
1	VSC 501*	Production of Cool Season Vegetable Crops	2+1
2	VSC 502*	Production of Warm Season Vegetable Crops	2+1
3	VSC 503*	Growth and Development of Vegetable Crops	2+1
4	VSC 504*	Principles of Vegetable Breeding	2+1
5	VSC 505	Breeding of Self Pollinated Vegetable Crops	2+1
6	VSC 506	Breeding of Cross Pollinated Vegetable Crops	2+1
7	VSC 507	Protected Cultivation of Vegetable Crops	1+1
8	VSC 508	Seed Production of Vegetable Crops	2+1
9	VSC 509	Production of Underutilized Vegetable Crops	2+1
10	VSC 510	Systematics of Vegetable Crops	1+1
11	VSC 511	Organic Vegetable Production	1+1
12	VSC 512	Production of Spice Crops	2+1
13	VSC 513	Processing of Vegetables	1+1
14	VSC 514	Postharvest Management of Vegetable Crops	2+1
15	VSC 515	Nutrition of Vegetable Crops	2+1
16	VSC 516	Water Management in Vegetable Crops	1+1
17	VSC 517	Vegetable Based Cropping Systems	2+0
18	VSC 571	Qualifying Examination	0+2
19	VSC 581	Seminar-I	0+1
20	VSC 582	Seminar-II	0+1
21	VSC 591	Research	0+27

\* Compulsory among major courses

VSC 501 Production of Cool Season Vegetable Crops 2+1	VSC 501
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Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery, sowing/ planting time and methods, hrydroponics and aeroponics, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (grading, packaging and marketing), pest and disease management and production economics of crops.

Unit I : Bulb and tuber crops—Onion, garlic and potato.

Unit II : *Cole crops*—Cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and kale.

Unit III : Root crops—Carrot, radish, turnip and beetroot.

Unit IV : Peas and beans—Garden peas and broad bean.

Unit V : Leafy vegetables—Beet leaf, fenugreek, coriander and lettuce.

### Practicals

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

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VSC 502 Production of Warm Season Vegetable Crops 2	2+1	
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### Theory

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

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

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

Unit III : Cucurbits—Cucumber, melons, gourds, pumpkin and squashes.

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

Unit V : Leafy vegetables—Amaranth and drumstick.

### Practicals

- Scientific raising of nursery and seed treatment;
- Sowing, transplanting, vegetable grafting;
- Description of commercial varieties and hybrids;
- Demonstration on methods of irrigation, fertilizers and micronutrients application;
- Mulching practices, weed management;
- Use of plant growth substances in warm season vegetable crops;

- Study of nutritional and physiological disorders;
- Studies on hydroponics, aeroponics and other soilless culture;
- Identification of important pest and diseases and their control;
- Preparation of cropping scheme for commercial farms;
- Visit to commercial farm, greenhouse/ polyhouses;
- Visit to vegetable market;
- Analysis of benefit to cost ratio.

### **Suggested References**

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### Theory

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

- Unit II : Physiology of dormancy and germination—Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellilns, cyktokinins and abscissic acid; Application of synthetic PGRs including plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production.
- Unit III : Abiotic factors—Impact of light, temperature, photoperiod, carbon dioxide, oxygen and other gases on growth, development of underground parts, flowering and sex expression in vegetable crops; Apical dominance.
- Unit IV : Fruit physiology—Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening.
- Unit V : Morphogenesis and tissue culture—Morphogenesis and tissue culture techniques in vegetable crops; Grafting techniques in different vegetable crops.

### Practicals

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

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- Kalloo G. 2017. Vegetable grafting: Principles and practices. CAB International Krishnamoorti HN. 1981. Application growth substances and their uses in agriculture. TataMcGraw Hill, New Delhi.
- Leopold AC and Kriedemann PE. 1981. *Plant growth and development*, Tata McGraw-Hill, New Delhi.
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- Saini *et al.* (Eds.). 2001. *Laboratory manual of analytical techniques in horticulture*. Agrobios, Jodhpur.
- Wien HC. (Eds.). 1997. The physiology of vegetable crops. CAB International.

- Unit I : Importance, history and evolutionary aspects of vegetable breeding and its variation from cereal crop breeding. Centers of origin and their role in crop improvement, germplasm introduction, conservation, exploitation and plant introduction.
- Unit II : Breeding systems and methods: Selection Procedures: Pure line selection in vegetable crops. Breeding methods to handle segregating generations: Pedigree and Bulk method of breeding, Back cross breeding and modifications to improve vegetable crops.
- Unit III : Population improvement methods: Mass selection and modifications and recurrent selection methods in vegetable improvement.
- Unit IV : Heterosis breeding-Types, mechanisms and basis of heterosis, steps involved in heterosis breeding, Economic  $F_1$  seed production systems and facilitating mechanisms like male sterility, self-incompatibility and sex forms.
- Unit V : Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.
- Unit VI : 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 nutrient use efficiency (NUE).

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

### Practicals

- Floral biology and pollination behavior of different vegetables;
- Techniques of selfing and crossing of different vegetables, viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper etc.;
- Breeding systems and handling of filial generations of different vegetables;
- Working out biometrical parameters chi–square, coefficients of variation, heritability, Genetic gain, hybrid vigour, correlation and regression etc.
- Exposure to biotechnological lab practices;
- Visit to breeding farms.

### **Suggested Referencess:**

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Gardner E J.1975. Principles of genetics. JohnWiley and Sons.

- Hayes H K, Immer F Rand Smith D C. 1955. Methods of plant breeding. McGraw-Hill.
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Ravindra Mulge, 2021, Vegetable Crops Breeding, NIPA, New Delhi and CRC Press, Taylor & Francis Group London, New York.

Simmonds N W.1978.Principles of crop improvement. Longman.

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

VSC 505	Breeding of Self Pollinated Vegetable Crops	2+1

### 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 assisted breeding; QTLs, PPV & 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

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

## **Suggested Referencess:**

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

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- Dhillon B S,Tyagi R K, Saxena S and Randhawa G J.2005, Plant genetic resources: horticultural crops. Narosa Publ. House.
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- Hazra P and Som M G.2015. Vegetable science (Second revised edition), Kalyani publishers, Ludhiana,598p.
- Hazra P and Som M G.2016. Vegetable seed production and hybrid technology (Second revised edition), Kalyani Publishers, Ludhiana, 459p
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- Singh B D.1983. Plant Breeding. Kalyani Publishers, New Delhi.
- Swarup V. 1976. Breeding procedure for cross-pollinated vegetable crops.ICAR.

VSC 506	Breeding of Cross Pollinated Vegetable Crops	2+1
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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, beetroot and onion. Unit IV : Tuber crops—Sweet potato, tapioca, taro and yam.

Unit V : Leafy vegetables—Beet leaf, spinach, amaranth and coriander.

## Practical

- Floral mechanisms favouring cross pollination;
- Development of inbred lines;
- Selection of desirable plants from breeding population;
- Observations and analysis of various quantitative and qualitative traits in germplasm, hybrids and segregating generations;
- Induction of flowering, palynological studies, selfing and crossing techniques;
- Hybrid seed production of vegetable crops in bulk;
- Screening techniques for biotic and abiotic stress resistance in above mentioned crops;
- Demonstration of sib-mating and mixed population;
- Molecular marker techniques to identify useful traits invegetable crops and special breeding techniques;
- Biometrics: path analysis, scaling test and components of generation means and stability analysis.
- Visit to breeding blocks.

## **Suggested Referencess:**

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

VSC 507 Protected Cultivation of Vegetable Crops 1+1	VSC 507	Protected Cultivation of Vegetable Crops	1+1
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- 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 structuresgreenhouse/ 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 soil-less media for bed preparation; Design and installation of drip irrigation and fertigation system.
- Unit III : Abiotic factors- Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity, etc. on growth and yield of different vegetables.
- Unit IV : Nursery raising- High tech vegetable nursery raising in protected structures using plugs and portrays, different media for growing nursery under protected cultivation; Nursery problems and management technologies including fertigation.
- Unit V : Cultivation of crops- Regulation of flowering and fruiting in vegetable crops; Technology for raising tomato, sweet pepper, cucumber and other vegetables in protected structures, including varieties and hybrids, training, pruning and staking in growing vegetables under protected structures.
- Unit VI : Solutions to problems- Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for seed production; Economics of greenhouse crop production.

## Practical

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

## **Suggested References**

- Chadha KL and Kalloo G. (Eds.). 1993-94. Advances in horticulture. Malhotra Pub. House. Chandra S and Som V. 2000. Cultivating vegetables in green house. Indian horticulture 45:17-18.
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- Singh S, Singh B and Sabir N. 2014. Advances in protected cultivation. New India publishing agency, New Delhi.
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# VSC 508 Seed Production of Vegetable Crops 2+1

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

## Practical

- Study of floral biology and pollination mechanisms in vegetables;
- Determination of modes of pollination;
- Field and seed standards;
- Use of pollination control mechanisms in hybrid seed production of important vegetables;
- Maturity standards and seed extraction methods;
- Seed sampling and testing;
- Visit to commercial seed production areas;
- Visit to seed processing plant;
- Visit to seed testing laboratories.

## Suggested References

- Agarwaal P K and Anuradha V. 2018. Fundamentals of seed science and technology. Brilliant publications, New Delhi.
- Agrawal PK and Dadlani M. (Eds.). 1992. Techniques in seed science and technology. South asian Publ.

Agrawal RL. (Ed.). 1997. Seed technology. Oxford and IBH.

- Basra AS. 2000. Hybrid seed production in vegetables. CRC press, Florida, USA.
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VSC 509	Production of Underutilized Vegetable Crops	2+1
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### Theory

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

- Unit I : Stem and bulb crops—Asparagus, leek and chinese chive
- Unit II : Cole and salad crops—Red cabbage, chinese cabbage, kale, sweet corn and baby corn
- Unit III : Leafy vegetables—Celery, parsley, indian spinach (poi), spinach, chenopods, chekurmanis and indigenous vegetables of regional importance
- Unit IV : Gourds and melons—Sweet gourd, spine gourd, teasle gourd, round gourd, and little/ Ivy gourd, snake gourd, pointed gourd, kachri, long melon, snap melon and gherkin

Unit V : Yam and beans-Elephant foot yam, yam, yam bean, lima bean and winged bean

### Practicals

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

### Suggested References

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

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

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

- Peter KV. (Eds.). 2007-08. Underutilized and underexploited horticultural crops. Vol.1-4, New India publishing agency, Lucknow.
- Peter KV and Hazra P. (Eds). 2012. Hand book of vegetables. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
- Peter KV 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 MK. 2018. Vegetable crop science. CRC Press Taylor and Francis Group 6000 Broken Sound Parkway NW, Suite 300 Boca Raton, FL 33487-2742 ISBN: 978-1-1380-3521-8

Rubatzky VE and Yamaguchi M. 1997. World Vegetables: Principles, Production and Nutritive Values. Chapman Hall (ITP), New York.

### VSC 510 Systematics of Vegetable Crops 1+1

### Theory

- Unit I : Significance of systematics 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

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

#### **Suggested References**

- Chopra G L. 1968. Angiosperms- systematics and life cycle. S. Nagin Dutta AC. 1986. A class book of botany. Oxford Univ. Press.
- Pandey BP. 1999. Taxonomy of angiosperm. S. Chand and Co
- Peter KV and Pradeep kumar T. 2008. Genetics and breeding of vegetables. (Revised), ICAR.
- Peter KV and Hazra P. (Eds). 2012. Hand book of vegetables. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
- Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables Volume II. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509p.
- Peter KV and Hazra P. (Eds). 2015. Hand book of vegetables Volume III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634p.

Simmonds NW and Smartt J. 1995. Evolution of crop plants.

- Wiley-Blackwell. Soule J. 1985. Glossary for Horticultural Crops. John Wiley and Sons.
- Srivastava U, Mahajan RK, Gango padyay KK, Singh M and Dhillon BS. 2001. Minimal descriptors of agri-horticultural crops. Part-II: Vegetable Crops. NBPGR, New Delhi.

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

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

- Unit I : Importance and principles—Importance, principles, perspective, concepts and components of organic farming in vegetable crops
- Unit II : Organic production of vegetables—Organic production of vegetable crops, viz., Solanaceous, Cucurbitaceous, Cole, root and tuber crops
- Unit III : Managing soil fertility—Managing soil fertility, mulching, raising green manure crops, weed management in organic farming system; Crop rotation in organic production; Processing and quality control of organic vegetable produce
- Unit IV : Composting methods—Indigenous methods of composting, Panchyagavvya, Biodynamics preparations and their application; ITKs in organic vegetable farming; Role of botanicals and bio-control agents in the management of pests and diseases in vegetable crops
- Unit V : Certification and export—Techniques of natural vegetable farming, GAP and GMP- certification of organic products; Export- opportunity and challenges

### Practicals

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

### **Suggested References**

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

- Gehlot G. 2005. Organic farming; standards, accreditation certification and inspection. Agrobios.
- Palaniappan SP and Annadorai K. 2003. Organic farming, theory and practice. Scientific publ.
- Pradeep kumar T, Suma B, Jyothi bhaskar and Satheesan KN. 2008. Management of horticultural crops. New India Publ. Agency.
- Shivashankar K. 1997. Food security in harmony with nature. 3rd IFOAM ASIA, Scientific Conf. 1- 4 December, UAS, Bangalore.

vsc siz   Production of Spice Crops   2+1
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### 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

#### Practicals

- Identification of seeds and plants;
- Botanical description of plant
- Preparation of spice herbarium
- Propagation
- Nursery raising
- Field layout and method of planting
- Cultural practices
- Harvesting, drying, storage, packaging and processing
- Value addition
- Short term experiments on spice crops.

#### **Suggested References**

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

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

- Bhattacharjee SK. 2000. Hand book of aromatic plants. Pointer publications.
- Bose TK, Mitra SK, Farooqi SK and Sadhu MK. (Eds.). 1999. *Tropical horticulture*.Vol.I. Naya Prokash.
- Chadha KL and Rethinam P. (Eds.). 1993. *Advances in horticulture*. Vols. IX-X. *Plantation crops and spices*. Malhotra Publ. House.
- Gupta S. (Ed.). *Hand book of spices and packaging with formulae*. engineers India research institute, New Delhi.
- Kumar NA, Khader P, Rangaswami and Irulappan I. 2000. Introduction to spices, plantation crops, medicinal and aromatic plants. Oxford and IBH.

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

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

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

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

- Pruthi JS. 2001. *Minor spices and condiments- crop management and post-harvest technology*, ICAR.
- Purseglove JW, Brown EG, Green CL and Robbins SRJ. (Eds.). 1981. Spices. Vols. I, II. Longman.
- Shanmugavelu KG, Kumar N and Peter KV. 2002. *Production technology of spices and plantation crops*. Agrobios.
- Thamburaj S and Singh N. (Eds.). 2004. Vegetables, tuber crops and spices. ICAR.
- Tiwari RS and Agarwal A. 2004. *Production technology of spices*. International Book Distr. Co.

Varmudy V. 2001. *Marketing of spices*. Daya Publ. House.

### 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 waste management.

## **Suggested References**

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

Chadha DS. 2006. The Prevention of food adulteration act. Confed. of Indian Industry.

Desrosier NW. 1977. Elements and technology. AVI Publ. Co.

FAO. 1997. Fruit and Vegetable processing. FAO.

FAO. CODEX Alimentarius: Joint FAO/ WHO food standards programme. 2nd Ed. Vol. VB tropical fresh fruits and vegetables. FAO.

FAO. Food quality and safety systems- training manual on food hygiene and haccp. FAO. Fellow's P. 1988. Food processing technology. Ellis Horwood International.

Fellow ST. 1988. Food processing reenhology. Enis Horwood International.

- Frazier WC and Westhoff DC. 1995. Food microbiology. 4th Ed. Tata McGraw Hill.
- Giridharilal GS Siddappa and Tandon GL. 1986, Preservation of fruits and vegetables. ICAR.
- Gisela J. 1985. Sensory evaluation of food- theory and practices. Ellis Horwood.
- Graham HD. 1980. Safety of foods. AVI Publ. Co.
- Hildegrade H and Lawless HT. 1997. Sensory evaluation of food. CBS.
- Joslyn M and Heid Food processing operations. AVI Publ. Co.
- Mahindru SN. 2004. Food safety: concepts and reality. APH Publ. Corp.
- Ranganna S. 1986. Handbook of analysis and quality control for fruit and vegetable products. 2nd Ed. Tata-McGraw Hill.
- Shapiro R. 1995. Nutrition labeling handbook. Marcel Dekker.
- Srivastava RP and Kumar S. 2003. Fruit and vegetable preservation: principles and practices.3rd Ed. International Book Distri. Co.
- Tressler and Joslyn MA. 1971. Fruit and vegetable juice processing technology. AVI Publ. Co.
- Verma LR and Joshi VK. 2000. Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management. Indus Publ. Co.

v SC 514   1 Osthar vest Management of vegetable Crops 211
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## Theory

Unit I

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

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

Unit III

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

Unit IV

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

Unit V

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

### Practical

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

### **Suggested References**

- Chadha KL and Pareek OP. 1996. Advances in horticulture. Vol. IV. Malhotra Publ. House.
- Chattopadhyay SK. 2007. Handling, transportation and storage of fruit and vegetables. Gene-Tech books, New Delhi.
- Haid NF and Salunkhe SK. 1997. Postharvest physiology and handling of fruits and vegetables.Grenada Publ.
- Mitra SK. 1997. Postharvest physiology and storage of tropical and sub-tropical fruits. CABI.
- Paliyath G, Murr DP, Handa AK and Lurie S. 2008. Postharvest biology and technology ofFruits, vegetables and flowers. Wiley-Blackwell, ISBN: 9780813804088.
- Ranganna S. 1997. Handbook of analysis and quality control for fruit and vegetable products.Tata McGraw-Hill.
- Stawley JK. 1998. Postharvest physiology of perishable plant products. CBS publishers.
- Sudheer KP and Indira V. 2007. Postharvest technology of horticultural crops. New India Publ.Agency.
- Thompson AK. (Ed.). 2014. Fruit and vegetables: harvesting, handling and storage (Vol. 1 and 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.
- Verma LR and Joshi VK. 2000. Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management. Indus Publishing Company, New Delhi, India. ISBN 8173871086.
- Willis R, McGlassen WB, Graham D and Joyce D. 1998. Postharvest: An introduction to the physiology and handling of fruits, vegetables and ornamentals. CABI.
- Wills RBH and Golding J. 2016. Postharvest: an introduction to the physiology and handling of fruit and vegetables, CABI Publishing, ISBN 9781786391483.
- Wills RBH and Golding J. 2017. Advances in postharvest fruit and vegetable technology, CRC Press, ISBN 9781138894051.

- Mineral nutrition in relation to problematic soils. Organic farming, soil less culture. Fertigation, slow release fertilizers.
- UNIT I : Historical background, criteria of essentiality of nutrient elements, clasification of plant nutrients and their role. Factors affecting nutrition, nutrient uptake and removal; techniques for evaluating nutrient requirements. Symptoms of deficiency and toxicity–their corrective measures. Nutritional disorders. Leaf sampling techniques, nutrient diagnostic techniques (DRIS), index tissue and nutrient standards.
- UNIT II : Role of nutrients and their response;
- UNIT III :Deficiency and toxicity disorders associated with different minerals, Manures and fertilizers- their composition and availability of essential nutrients.
- UNIT IV : Biofertilizers classification, Vermicuture and vermicomposting. Integrated nutrient management. Effects of nutrient elements on growth, yield and quality. Application of different nutrients; soil and foliar nutrient levels related to crop production of different vegetable crops.

## Practicals

- Study of diagnostic techniques for determining nutrient status of crops.
- Preparation of nutrient solutions, sand culture and hydroponics.
- Identification of deficiency symptoms of different mineral nutrients and their correction, determination of level of toxicity of nutrients.
- Study of root distribution, leaf sampling techniques.
- Chemical analysis of different nutrients in different parts of plants and soils.
- Visit to long term fertilizer experimental plots in research.

## **Suggested References**

- Mitra, SK,. Sadhu ML and Bose TK. 1990. Nutrition of Vegetable Crops. Naya. Prokash. Calcutta, 700006, India
- Rai, N. and Yadav, D. S. (2005). Advances in Vegetable production. Research co Book
- Bose, Kabir, Maity, Parthasarathy and Som- Vegetable crops, Vol. I, II and III Chadda K.L; Advances in horticulture, Vol. 5 and 6

Thompson HC and Kelly WC. (Eds.). 1978. Vegetable crops. Tata McGraw-Hill.

Hazra and Som – Technology for vegetable production and improvement. Naya Prakash.

VSC 516	Water Management in Vegetable Crops	1+1
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## Theory

UNIT I : History and development of irrigation and water resources in India.

UNIT II : Soil-water-plant relationships. Determination of soil moisture and measurement of irrigation water. Criteria for scheduling irrigations, determination of water requirement for vegetable crops.

UNIT III : Consumptive use, soil moisture extraction pattern and water use efficiency.

UNIT IV : Quality of irrigation water, methods of irrigation. Soil moisture in relation to growth, productivity and quality. Efficient water use techniques.

UNIT V :Drainage and Water management practices for important of vegetable crops.

## Practicals

- Determination of soil moisture using various techniques.
- Measurement of water flow and calculation of irrigation efficiencies.
- Scheduling of irrigation to vegetable crops by various methods.
- Working out consumptive use and water requirement of vegetable crops.
- Preparation of cropping plan based on irrigation requirement of crops.
- Visit to commercial vegetable farms equipped with modern irrigation systems.

### Suggested References

- Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. Vegetable Crops. Vols. I–III. Naya Udyog.
- Chadha K L& Kalloo G. (Eds.). 1993–94. Advances in Horticulture. Vols. V–X. Malhotra Publ. House.
- Hazra P & Som MG. (Eds.). 1999. Technology for Vegetable Production and Improvement. Naya Prokash.
- Rana MK. 2008. Scientific Cultivation of Vegetables. Kalyani.
- Marcel Dekker. Shanmugavelu KG. 1989. Production Technology of Vegetable Crops. Oxford & IBH.
- Singh DK. 2007. Modern Vegetable Varieties and Production Technology. International Book Distributing Co.
- Singh NP, Bharadwaj AK, Kumar A & Singh KM. 2004. Modern Technology on Vegetable Production. International Book Distributing Co.
- Singh SP. (Ed.). 1989. Production Technology of Vegetable Crops. Agril. Comm. Res. Centre.

Thamburaj S & Singh N. 2004. Textbook of Vegetables, Tuber Crops and Spices. ICAR. Thompson HC & Kelly WC. (Eds.). 1978. Vegetable Crops. Tata Mc Graw Hill.

VSC - 517	Vegetable Based Cropping Systems	2+0
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### Theory

- UNIT I :Cropping systems, importance, objectives, scope in the tropics with special reference to Indian conditions.
- UNIT II : Principles, definitions of terms- multiple, relay and multistoried cropping.
- UNIT III : Population and geometry of planting of associated crops.
- UNIT IV : Competitive and complementary effects.
- UNIT V : Crop intensification in vegetable crops.

### **Suggested References**

- Arsanti I. W. and Böhme M. H. 2008. Evaluation of Profitability and Competitiveness of Vegetable Farming Systems in Upland Areas of Indonesia, Proc. IInd on Supply Chains in Transit. Econ. Acta Hort., 774: 49–54
- Baniya N. 2008. Land Suitability Evaluation Using GIS For Vegetable Crops in Kathmandu Valley /Nepal. A PhD dissertation, Humboldt–University of Berlin, Germany

- Dixon J., Gulliver A., Gibbon D. 2001. Farming Systems and Poverty Improving Farmers' livelihoods in changing world – FAO and World Bank, Rome, Italy; Principal Editor Malcolm Hall.
- FAO. 1986. Land evaluation for development: Food and Agriculture Organization of the United Nations,
- Rome, Italy: 4–59 (74p).
- T.K. Bose, M.G. Som, J. Kabir Vegetable crops ...
- Shanmugavelu Production technology of vegetable crops
- S.P. Singh, Principles of vegetable production
- Thompson, H C and Kelly, W C. 1999. Vegetable crops. 5th Edition, McGraw Hill Publishing Co. Ltd., New Delhi
- Yawalkar, K.S. Vegetable crops of India . 1965. Agri-Horticultural Publishing House
- H.P. Singh, 2008, Technology interventions in Indian Horticulture A way ahead. Indian Horticulture, 52(4): 1–9.

Sl.	Course	Course Title	Courd's Harris
No.	No.		Credit Hours
Major	courses (Mi	nimum 20 Credits)	•
1	FLS 501	Systematics of Ornamental Plants	2+1
2	FLS 502*	Breeding of Ornamental Plants	2+1
3	FLS 503	Commercial Production of Cut Flowers	2+1
4	FLS 504*	Commercial Production of Loose Flowers	2+1
5	FLS 505*	Ornamental Gardening and Landscaping	2+1
6	FLS 506	Indoor Plants and Interior scaping	1+1
7	FLS 507	Nursery Management in Ornamental Plants	2+1
8	FLS 508	Turf Grass Management	2+1
9	FLS 509	Value Addition in Floriculture	2+1
10	FLS 510*	Protected Cultivation of Flower Crops	2+1
11	FLS 511*	CAD for Landscaping	1+1
12	FLS 512	Seed Production in Flower Crops	1+1
13	FLS 513	Growth Regulators in Floriculture	1+1
14	FLS 514	Bulbous Ornamental Plants	1+1
15	FLS 515	Minor Flower Crops	1+1
16	FLS 516	Weed Management in Flowers and Ornamental Crops	1+1
17	FLS 571	Qualifying Examination	0+2
18	FLS 581	Seminar-I	0+1
19	FLS 582	Seminar-II	0+1
20	FLS 591	Research	0+27

# FLORICULTURE AND LANDSCAPING

\* Compulsory among major courses

FLS 501

#### Theory

- Block I: Nomenclature
- Unit I: Nomenclature: History, origin, hotspots, classification and nomenclature systems.
- Unit II: International systems: International Code, Treaties, International and National Organizations, Biodiversity Act, Identification features, descriptors.
- Unit III: Red Book, Registration (NBPGR, PPVFRA, NBA).
- Block2: Families
- Unit I: Families: Description and families and important genera Rosaceae, Asteraceae, Solanaceae, Caryophyllaceae, Apocynaceae, Arucariaceae, Araceae, Liliacae. Rutaceae, Verbinaceae, Araceae etc..
- Unit II: Acanthaceae, Palmaceae, Cycadaceae, Asparagaceae, Malvaceae, Rubiaceae, Musaceae, Oleaceae, Cactaceae, Iridaceae, Araceae, polypodiaceae etc..
- Block 3: Molecular techniques
- Unit I: Molecular techniques in modern systematics.

#### Practical

Different nomenclature systems of plants (2);

Plant morphology and taxonomic description, Importance and uses of different commercial flowers, annuals, bulbous ornamentals, climbers, shrubs, trees, indoor plants, palms and cycads, ferns and sellagenellas, cacti and succulents (8);

Cryopreservation and tissue culture repository (1);

Molecular techniques (1).

#### **Suggested References**

- Bhattacharya, B. and Johri, B. M., .2004. *Flowering Plants:Taxonomy and Phylogeny*. Narosa Publ. House, NewDelhi, 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., and Haribabu, R. S., 2014. Citriculture, Kalyani Publishers, New Delhi, India. SpencerRR, CrossRandLumleyP.2007.PlantNames.3rdEd. A Guide to Botanical Nomenclature. CSIRO Publ., Australia.,176p.
- Vasistha B. B.1998. Taxonomy of Angiosperms. Kalyani Publishers, New Delhi, India.

- Block 1: Principles of Plant Breeding
- Unit I: Principles of plant breeding: Principles, 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 and DUS testing in flower crops.
- Unit III: Genetic mechanisms and inheritance: 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 objectives, breeding methods suitable for sexually, as exually propagated flower crops, self- and cross-pollinated crops: pedigree selection, backcross, clonal selection, polyploidy and mutation breeding, heterosis and  $F_1$  hybrids.
- Unit II: Role of biotechnology: Role of biotechnology in improvement of flower crops including, soma-clonal variation, *in-vitro* mutagenesis, *In-vitro* selection, genetic engineering, molecular markers, etc.

Crops

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

### Practical

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

### **Suggested References**

Bhattacharjee S K.2018., *Advances in Ornamental Horticulture*. Pointer Publ., Reprint, 6vols, pp.2065.

Bose T K and Yadav LP. 1989, Commercial flowers. Naya Prokash, Kolkata, India.

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

Chadha KL and Bhattacharjee 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 and Choudhury B. 1992. *Ornamental Horticulture in India*. ICAR, NewDelhi, India.
- Chaudhary R C. 1993. Introduction to Plant Breeding. Oxford & IBH Publ.
- Misra R L and Misra S. 2017. *Commercial Ornamental Crops: Cut Flowers*. Kruger Brentt Publisher UK Ltd. pp. 584.
- Misra R L and Misra S. 2017. *Commercial Ornamental Crops: Traditional and Loose Flowers*.
- Kruger Brentt Publisher UKLtd.
- Singh B D .2016. *Plant Breeding Principles and Methods*. Kalyani Publishers, New Delhi-Ludhiana, India.
- Vainstein A.(Ed). 2002. Breeding for ornamental crops: Classical and Molecular Approaches.
- Springer-Science-Business Media, B. V. Edition1. pp.392.
- Watts L. 1980. *Flower and Vegetable Plant Breeding*. Unilever Research, Sharnbrook, Bedford, UK. pp182. Grower Books, London, UK.

FLS 505 Commercial Production of Cut Flowers 2+1	FLS 503	Commercial Production of Cut Flowers	2 + 1
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- Block1: 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 physical and physiological interventions, chemical regulation, environmental manipulation.
- Block 2: Post-harvest management and marketing
- Unit I: Post harvest management: Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Methods of delaying flower opening, Pre-cooling, pulsing, packing, storage and transportation.
- Unit II: Marketing: Marketing, export potential, institutional support, Agri Export Zones, 100% Export Oriented units, Crop Insurance.
- Crops: Rose, chrysanthemum, gladiolus, tuberose, carnation, gerbera, orchids, lilium, anthurium, China aster, alstoemeria, bird of paradise, heliconia, alpinia, gypsophila, golden rod, limonium, stock, celosia, cut greens and fillers.

## Practical

- Identification of varieties (1)
- Propagation (2)
- Micro-climate management(2)

- Training and pruning techniques (1)
- Pinching, deshooting, disbudding, desuckering (1)
- Practices in manuring, drip and fertigation, foliar nutrition, growth regulator application(2)
- Harvesting techniques, post-harvest handling, cold chain(2)
- Economics, Project preparation for regionally important cut flowers, crop specific guidelines for project financing (NHB guidelines) (2)
- Visit to commercial cut flower units (2)
- Case studies (1)

### **Suggested References**

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

- Block1: 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 disorder sand 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: Postharvest management and marketing
- Unit I: Postharvest 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, spiderlily, hibiscus, nerium, barleria, gomphrena, tabernaemontana (Chandni), lotus, water lily, nerium, michelia(Champaka), zinnia

## Practical

- Identification of species and varieties (1)
- Propagation and nursery management (1)
- Training and pruning techniques (1)
- Fertigation, foliar nutrition, growth regulator application (2)
- Crop protection (2)
- Pinching, disbudding, staking, harvesting techniques (1)
- Post-harvest handling, storage and cold chain (2)
- Project preparation for regionally important commercial loose flowers. crop specific guidelines for project financing (NHB guidelines) (2)
- Cost Economics (2)
- Exposure Visits to fields (2)

## **Suggested References**

- 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.
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- Prasad S and Kumar U. 2003. Commercial Floriculture. Agrobios Publ., Jodhpur.

Randhawa G S and 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
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### Theory

- Block1: 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 grooves, bonsai; Non -living components like-path, garden gate, fencing, paving and garden features like fountains, garden seating, swings, lanterns, basins, birdbaths, sculptures, waterfalls, bridge, steps, ramps, Lawn- genera and species, establishment and maintenance.
- Unit III: Specialized gardens: Specialized 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, programme space, 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, airports, railway station and tracks, river banks and dam sites and IT/ SEZ parks. Bio-aesthetic planning, ecotourism, theme parks, indoor gardening, therapeutic gardening and xeriscaping

### Practical

- Graphic language and symbols in landscaping, study of drawing instruments, viz., 'T' square, setsquare, drawing board, etc.(1)
- Identification of various types of ornamental plants for different gardens and occasions (1)
- Preparation of land, planning, layout and planting, deviations from landscape principles (1); Case study (1)
- Site analysis, interpretation of map of different sites, use of GIS for selection (1)
- Enlargement from blue print. Landscape design layout and drafting on paper as per the scale (2)

- Preparation of garden models for home gardens, farm houses, Industrial gardens, institutional gardens, corporate, avenue planting, practices in planning and planting of special types of gardens.(3)
- Burlapping, lawn making, planting of edges, hedges, topiary, herbaceous and shrubbery borders (2)
- Project preparation on landscaping for different situations, creation of formal and in formal gardens(2)
- Visit to parks and botanical gardens (2)

### **Suggested References**

- Bose T K, Chowdhury Band Sharma S P. 2011. *Tropical Garden Plants in Colour*. Hort. And Allied Publ.
- Bose T. K., Maiti.R. G., Dhua. R S. and Das P. 1999, *Floriculture and Landscaping*. Naya Prakash, Kolkata, India.
- Grewal H S and SinghP. 2014. Landscape Designing and Ornamental Plants. Kalyani Publishers, NewDelhi.
- Lauria A and Victor, H R. 2001. *Floriculture Fundamentals and Practices*. Agrobios Publ., Jodhpur.
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- Nambisan K M P. 1992. *Design Elements of Landscape Gardening*. Oxford & IBH Publ. Co., New Delhi, India.
- Randhawa G S and Mukhopadhyay A. 1986. Floriculture in India. Allied Publ.
- Sabina G T and Peter K V. 2008. Ornamental Plants for Gardens. New India Publ. Agency, NewDelhi, India.
- Singh A and 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 and 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 - 506Indoor Plants And Interior Scaping1	+1	
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- Block 1: Scope, principles and operations
- Unit I: Importance and scope: Importance and scope of indoor plants and Interior scaping, 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, And 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

### Practical

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

# **Suggested References**

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

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

FL	LS 507	Nursery Management for Ornamental Plants	2 + 1

#### 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, meristemculture. 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, soilless 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

- Anatomical studies in rooting of cutting and graft union (2)
- Identification and production of plug plants, seedlings and saplings(2)
- Preparation of growing media and use of PGRs(2);
- Practice of propagation through specialized structures cuttings, layering, budding and grafting(2)
- Case studies (2)
- Micro propagation of ornamental crops and hardening(3)
- Visit to tissue culture labs and nurseries(2)
- Economics (1)

## **Suggested References**

- Adriance G Wand Brison F R. 2000. *Propagation of Horticultural Plants*. Biotech Books, New Delhi, India.
- Bose T K, Mitra S K and Sadhu M K. 1991 .*Propagation of Tropical and Sub tropical Horticultural Crops*. Naya Prokash, Kolkata, India.
- Chadha K L, Ravindran P L and 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 and Kester D L. 2018. *Hartmann and Kester's Plant Propagation: Principles and Practices.* Pearson Publ. 9<sup>th</sup> Edition.
- Peter K V. 2008. Basics of Horticulture. New India Publ. Agency, New Delhi, India.
- Rajan Sand 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., NewDelhi, India.

FLS 508TURF GRASS MANAGEMENT2+1
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- Block1: Turf industry and turf grasses
- Unit I: Prospects and basic requirement: History, present status and prospects of turf industry; basic requirements, sites election 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 micro nutrients, 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 or different grounds
- Unit I: Making of different sports arenas: Establishment and maintenance of turfs for playgrounds, viz., golf, football, hockey, cricket, tennis, rugby, residential and

public parks, turfing of Govt. and Corporate office gardens, event specific preparation, turf colourants.

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

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

### **Suggested References**

- 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 and 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 AJ. 1980. *Turf grass Management*. Reston Publ. Inc.

FLS 509	Value Addition in Floriculture	2 + 1
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- 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, rosewater, 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. Edible flowers, flower waste management and encapsulation of flowers
- 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**

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

### **Suggested Referencess**

- Bhattacharjee S K. 2018. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ. Reprint, pp. 2065.
- Chadha K L and Bhattacharjee S K. 1995. *Advances in Horticulture: Ornamental Plants*. Vol.XII, Parts1 & 2. pp.533 and pp.574. Malhotra Publ.House,New Delhi,India.
- Lauria A and Victor H R.2001. *Floriculture Fundamentals and Practices*. Agrobios Publ., Jodhpr.
- Nowak J and Rudnicki R M. 1990. Postharvest handling and storage of cut flowers, florist greens and potted plants. Timber Press, USA.pp.210.
- Prasad S and Kumar U. 2003. Commercial Floriculture. Agrobios Publ., Jodhpur.
- Reddy S, Janakiram T, Balaji T, Kulkarni S and Misra RL. 2007. Hi- Tech

Floriculture. Indian Society of Ornamental Horticulture, New Delhi, India.

FLS 510	Protected Cultivation of Flower Crops	2+1
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- Block 1: Principles and types
- Unit I: Prospects and types of protected structures: Prospects of protected floriculture in India; Types of protected structures–Glasshouse/polyhouse, shadenet houses, mist chambers, lath houses, orchidarium, fernery, rain shelters, etc.
- Unit II: Principles and design: Principles of designing and erection of protected structures; Low cost / Medium cost / High cost structures; Location specific designs; Structural components; Suitable flower and foliage plants for protected cultivation.
- Block 2: Growing environment
- Unit I: Control of environment: Microclimate management and manipulation of temperature, light, humidity, air and CO<sub>2</sub>; Heating and cooling systems, ventilation, naturally ventilated green houses, 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, staking and netting etc.) Photoperiod regulation.

- Unit III: Automation and standards: Automation in greenhouses, sensors, solar green houses and retractable greenhouses, GAP/Flower labels, Export standards, EXIM Policy, APEDA, regulations,
- Crops: Rose, Chrysanthemum, Carnation, Gerbera, Orchids, Anthuriums, Lilium, Limonium, Lisianthus, Heliconia, Calalily, Alstromeria, Cut foliges etc.

#### Practical

- Study of various protected structures (1)
- Design, layout and erection of different types of structures(2)
- Practices in preparatory operations, growing media, soil decontamination techniques (2)
- Microclimate management(2)
- Practices in drip and fertigation techniques, special horticultural practices(2)
- Determination of harvestindices and harvesting methods(1)
- Post harvest handling, packing methods(1)
- Economics of cultivation, Project preparation(2)
- Project Financing guidelines(1)
- Visit to commercial greenhouses(2)

### **Suggested References**

- 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 and Das, P. 1999. Floriculture and Landscaping. NayaProkash,
- Bose, T.K and Yadav, L.P. 1989. Commercial Flowers. NayaProkash, Kolkata, India.
- Chadha,K.L and Bhattacharjee,S.K. 1995. Advancesin Horticulture: Ornamental Plants.Vol. XII, Parts1&2.pp.533 and pp.574. Malhotra Publ. House, NewDelhi, India.
- Lauria A and Victor, H.R .2001. Floriculture-Fundamentals and Practices. Agrobios Publ., Jodhpur.
- Nelson, P.V. 2011. Green House Operation and Management. Pearson Publ. 7<sup>th</sup> edition pp.624.
- Prasad, S. and Kumar, U. 2003. Commercial Floriculture. Agrobios Publ., Jodhpur Randhawa, G.S and Mukhopadhyay A.1986. Floriculture in India. Allied Publ.
- Reddy S, Janakiram T, Balaji T, Kulkarni S and Misra RL. 2007. Hi- Tech Floriculture. Indian Society of Ornamental Horticulture, New Delhi, India

<b>FLS 511</b>   CAD for Landscaping   1+1
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## Theory

Block 1: CAD

- Unit I: CAD basics and applications: Principles of integrating the Architecture and landscaping, Exposure to CAD (Computer Aided Designing)–Applications of CAD in landscape garden designing, 2Ddrawing by AUTOCAD, Creating legends for plant and non plant components, Basics of Photo shop software in garden designing.
- Unit II: 2Ddrawing: 2Ddrawing 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 Info box, 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 CDROM 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.

## Practical

- Practices in point picking methods, Using tool bars and icons, Using modifying tools and modifying comments(3)
- Isometric drawings, Using productivity tools(2);
- Drawing designs by AUTOCAD for home garden, institutional garden and special types of garden(2);
- Using tools and info-box for 3D drawing, Creation of garden components with ARCHICAD(2);
- Organization, dimensioning, detailing and visualization tools with ARCHICAD(2);
- Using Photoshop package for 3D picture insertion(1);
- Drawing designs with ARCHICAD for home garden, interior garden designing, IT parks, Corporates, Theme parks and Ecotourism spots(2);
- Exposure visits (2).

# **Suggested References**

- Christine, Wein-PingYu. 1987. Computer- aided Design: Application to Conceptual thinking Landscape Architecture. amazon.com.
- Misra R L and Misra S.2012, *Landscape Gardening*. Westville Publ. House, New Delhi, India.

- Block 1: Seed Industry
- Unit I: Scenario of Seed Industry : Scope, scenario and importance of seed production in flower crops. Constraints in flower seed production. Marketing and economics of flower seeds.
- Block2: Hybrid Seed Production
- UnitI: Seed production-Methods: Methods of seed production, agro techniques for production of nucleus, breeder and certified seeds. Harvesting, seed processing, seed priming, seedchain, 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 behavior 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 seed sand OGL, trade barriers in seed business, sanitary and phytosanitaty issues, custom clearance and quarantine.
- Crops : Marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, ornamental sunflower, annual chrysanthemum, poppy, cornflower, rice flower, China aster, gaillardia, stock, balsam, celosia, etc.,

### Practical

- Seed production of open pollinated varieties(2);
- Seed production of cross pollinated varieties(2);
- Steps involved in hybrid seed production(2);
- Hybridseedproductionindifferentflowercropslikemarigold,petunia,antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum, etc.(6);
- Visit to seed industry(3);
- Visit to quarantine facility (1).

### **Suggested References**

- Bhattacharjee, S.K. 2018. Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ. Reprint, pp.2065.
- Bose TK, Yadav LP, Pal P, Parthasarathy, V.A. and Das, P. 2003. Commercial Flowers. Vol.I & II. Naya Udyog, Kolkata, India.
- Davies, Fred T Jr, Geneve RL, Wilson SB, Hartmann HT. KesterDL.2018. Hartmann and Kester's Plant Propagation: Principles and Practices. Pears on Publ.9<sup>th</sup> Edition.
- Larson, R.A. and Armitage, A.M. 1992. Introduction of Floriculture. International Book Distributing Co., Lucknow, India.

FI S 512	Crowth Dogulators in Floriculture	1.1
LP 212	Growin Regulators in Floriculture	1+1

### Theory

Introduction, classification of growth regulators. Synthetic and naturally occurring growth substances. Biosynthesis, metabolism, physiological role and mode of action of different growth regulators and their role with respect to dormancy, promotion and retardation of growth, regulation of flowering, senescence and vase life of flowers.

### Practicals

Studies on growth with special reference to growth substances. Laying out of experiments by using different growth regulators on dormancy, apical dominance, rooting of cuttings, growth, flowering, senescence and abscission.

### **Suggested Referencess**

Bose, T.K., and Yadav, P., 1989. Commercial Flowers Prasad, S., and Kumar, U., 1998. Commercial floriculture Bhattacharjee, S.K., and L.C. De. 2003.Advanced Commercial Floriculture. Richard N. Arteca, 1997. Plant growth substances

Introduction and importance and scope for ornamental bulbous crops. Cultivation of bulbous crops for cut flowers, pot plants and bedding plants. Requirements of temperature, photoperiod and moisture for growth and flowering of important species, agro technique, plant protection, post harvest management.

### Practicals

Identification of different species / varieties / types. Techniques of cultivation and handling of bulbs, cut flowers and pot plants.

### Suggested Referencess

Bose & Yadav, 1989. Commercial flowers Surendra Prasad Updesh Kumar, 1998. Commercial floriculture Das, S.N. 2004.Growing Bulbous ornamental plants

FLS 515 Minor Flower Crops	1+1
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### Theory

Importance, history, origin, area and distribution, botany, propagation, crop improvement, varieties, production and cultivation, pests and diseases and post harvest technology of minor commercial flowers like Daisy, Bulbous crops-spider lily, calla lily, tiger lily, foot ball lily, Daffodil, narcissus, zinnia, gaillardia, solidago, calendula, and other seasonals etc.

### **Practicals**

Identifications, classification and description of commercial spices and varieties. Studies on propagation. Layout of experiments to prolong the vase life of cut flowers. Harvesting, grading, storing and packing of flowers. Use of growth regulators. Survey of cut flower markets. Visit to commercial flower gardens research centres and flower markets and auction centres.

### **Suggested Referencess**

Bose, T.K., and Yadav, P., 1989. Commercial Flowers Prasad, S., and Kumar, U., 1998. Commercial Floriculture Bob gibbons and Peter Brough, 1982.Wild flowers

FLS 516 Weed Management in Flowers	nd Ornamental Crops 1+1	
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### Theory

Weeds: Introduction, harmful and beneficial effects, classification, propagation and dissemination; Concepts of weed prevention, control and eradication; Methods of weed control: physical, cultural, chemical and biological methods. Integrated weed management; Herbicides:advantages and limitation of herbicide usage in India, Herbicide classification, formulations, methods of application; Introduction to adjuvants and their use in herbicides; Introduction to selectivity of herbicides; Compatibility of herbicides with other agro chemicals; Weed management in major flowers and ornamental crops, shift of weed flora in cropping systems, aquatic and problematic weeds and their control.

## Practicals

Identification of weeds; Survey of weeds in crop fields and other habitats; Preparation of herbarium of weeds; Calculations on weed control efficiency and weed index; Herbicide label information; Computation of herbicide doses; Study of herbicide application equipment and calibration; Demonstration of methods of herbicide application; Preparation of list of commonly available herbicides; Study of phytotoxicity symptoms of herbicides in different crops; Biology of nut sedge, bermuda grass, parthenium and celosia; Economics of weed control practices; Tours and visits of problem areas. Crops: Rose, gladiolus, gerbera, chrysanthemum, marigold, China aster, tuberose, bird of paradise, dahlia, golden rod, anthurium, lawn and other ornamentals.

### Suggested Referencess

Bose, T.K., and Yadav, P., 1989. Commercial Flowers Prasad, S., Kumar, U., 1998. Commercial Floriculture

S1.	Course	Course Title	Cradit Hours
No.	No.		Cledit Hours
Major	Major courses (Minimum 20 Credits)		
1	PSM 501*	Production of Plantation Crops	2+1
2	PSM 502*	Production of Spice Crops	2+1
3	PSM 503*	Production of Medicinal and Aromatic Crops	2+1
4	PSM 504*	Breeding of Plantation and Spice Crops	2+1
5	PSM 505*	Breeding of Medicinal and Aromatic Crops	1+1
6	PSM 506	Systematics of Plantation and Spice Crops	1+1
7	PSM 507	Systematics of Medicinal and Aromatic Crops	1+1
8	PSM 508	Underexploited Plantation, Spice, Medicinal and Aromatic Plants	2+0
9	PSM 509	Growth and Development of Plantation, Spice, Medicinal and Aromatic Crops	2+1
10	PSM 510	Biochemistry of Plantation, Spice, Medicinal and Aromatic Crops	2+1
11	PSM 511	Biodiversity and Conservation of Plantation, Spice, Medicinal and Aromatic Crops	2+1
12	PSM 512	Processing and Quality Analysis of Medicinal and Dye Plants	1+1
13	PSM 513	Natural Dye and Bio-pesticidal Plants	1+1
14	PSM 514	Bio-technology of Spices, Plantation, Medicinal and Aromatic Crops	1+1
15	PSM 515	Value Addition, By-product Utilization in Spices, Plantation, Medicinal and Aromatic Crops	1+1
16	PSM 516	Cropping Systems in Spices, Plantation, Medicinal and Aromatic Crops	1+1
17	PSM 517	Extraction, Storage and Quality Analysis of Essential Oils	1+1
18	PSM 571	Qualifying Examination	0+2
19	PSM 581	Seminar-I	0+1
20	PSM 582	Seminar-II	0+1
21	PSM 591	Research	0+27
* Con	npulsory amor	ng major courses	

# PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

Block 1: Importance of Plantation Crops

- Unit 1: Role of plantation crops: Role of plantation crops in national economy, areaproduction 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:OilpalmVarietal 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, Cashew, Coffee, Tea, Cocoa, Rubber, Palmyrah, Betel vine

### Practicals

- Description of botanical and varietal features;
- Selection of mother palms and seedlings;
- Nursery techniques;
- Soil and water conservation measures;
- Nutrient deficiency symptoms;
- Manuring practices;
- Pruning and training methods;
- Maturity standards;
- Harvesting;
- Project preparation for establishing plantations;
- GAP in plantation crops;
- Exposure visits to commercial plantations, research institutes.

### Suggested References

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

Anonymous. 1985. Rubber and its Cultivation. The Rubber Board of India.

Chopra VL and Peter KV. 2005. Handbook of Industrial Crops. Panima.

Choudappa P, Anitha K, Rajesh MK and Ramesh SV. 2017. *Biotechnology of Plantation Crops*. Daya Publishing House, New Delhi

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- Harler CR. 1963. The Culture and Marketing of Tea. Oxford Univ. Press.
- Joshi P. 2018. Text Book on fruit and plantation crops. Narendra Publishing House, New Delhi
- Kurian A and Peter KV. 2007. Commercial Crops Technology. New India Publ. Agency.
- Nair MK, Bhaskara Rao EVV, Nambia KKN and Nambiar MC. 1979. *Cashew*. CPCRI, Kasaragod.

Panda H. 2013. The Complete Book on Cashew. Asia Pacific Business Press Inc.

- Panda H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2<sup>nd</sup> Revised Edition). Asia Pacific Business Press Inc.
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- Pillay PNR. 1980. *Handbook of natural rbber production in India*. Rubber Research Institute, Kottayam. pp.668.
- Pradeepkumar T, Suma B, Jyothibhaskar and Satheesan KN. 2007. *Management of Horticultural Crops.* Parts I, II. New India Publ. Agency.
- Ramachandra et al. 2018. Breeding of Spices and Plantation crops. Narendra Publishing House, New Delhi.
- Ranganathan V. 1979. Hand Book of Tea Cultivation. UPASI, Tea Res. Stn. Cinchona.
- Sera T, Soccol CR, Pandey A, Roussos S Coffee Biotechnology and Quality. Springer, Dordrecht.
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- Sharangi AB and Acharya SK. 2008. *Quality management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2.
- Srivastava HC, Vatsaya and Menon, KKG. 1986. *Plantation Crops Opportunities and Constraints*. Oxford and IBH.

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

PSM 502	Production of Spice Crops	2+1
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### 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, Vanilla, Nutmeg, Clove, Cinnamon, Allspice, Tamarind, Garcinia,

## Practicals

- Identification of seeds and plants
- Botanical description of plant;
- Varietal features;
- Planting material production;
- Field layout and method of planting;
- Cultural practices;
- Harvest maturity, harvesting;
- Drying, storage, packaging;
- Primary processing;
- GAP in spice crops;
- GMP in spice crops;
- Short term experiments on spice crops;
- Exposure visits to spice farms, research institutes.

## **Suggested References**

Agarwal S, Sastry EVD and Sharma RK. 2001. Seed Spices: Production, Quality, Export. Pointer Publ.

Arya PS. 2003. Spice Crops of India. Kalyani.

- Bose TK, Mitra SK, Farooqi SK and Sadhu MK. Eds. 1999. *Tropical Horticulture*. Vol.I. Naya Prokash.
- Chadha KL and Rethinam P. Eds. 1993. Advances in Horticulture. Vols. IX-X. Plantation Crops and Spices. Malhotra Publ. House.
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- Kumar NA, Khader P, Rangaswami and Irulappan I. 2000. Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants. Oxford and IBH.
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- Parthasarthy VA, Kandiannan V and Srinivasan V. 2008. Organic Spices. New India Publ.Agency.
- Peter KV. 2001. *Hand Book of Herbs and Spices*. Vols. I-III. Woodhead Publ. Co. UK and CRC USA.
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- Pruthi JS. 2001. Minor Spices and Condiments- Crop Management and Post HarvestTechnology.ICAR.
- Purseglove JW, Brown EG, Green CL and Robbins SRJ. Eds. 1981. Spices. Vols. I, II. Longman.
- Ramachandra et al. 2018. Breeding of Spices and Plantation crops. Narendra Publishing House, New Delhi.
- Ravindran PN. 2000. Black pepper, Piper nigrum. CRC press.
- Ravindran PN. 2002. Cardamom, the genus Elettaria. CRC press
- Ravindran PN. 2003. Cinnamon and cassia. CRC press
- Ravindran PN. 2004. Ginger, the genus Zingiber. CRC press

Ravindran PN. 2007. Turmeric, the genus curcuma. CRC press

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- Shanmugavelu KG, Kumar N and Peter KV. 2002. Production Technology of Spices and Plantation Crops. Agrobios.
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- Sharangi AB. 2018. Indian Spices "*The legacy, production and processing of India's treasured export.*" Springer International publishing AG, Part of Springer Nature 2018, Cham, Switzerland.
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- Sharangi AB and Acharya SK. 2008. *Quality Management of Horticultural crops*. Agrotech Publishing House, Udaipur; ISBN: 81-8321-090-2.

Thamburaj S and Singh N. Eds. 2004. Vegetables, Tuber Crops and Spices, ICAR.

Tiwari RS and Agarwal A. 2004. *Production Technology of Spices*. International Book Distr.Co.

PSM 503	Production of Medicinal and Aromatic Crops	2+1
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#### 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, ashwagandha, glory lily, sarpagandha, *Aloe vera*, *Andrographis paniculata*, isabgol, opium poppy, safed

musli, Stevia rebaudiana, Mucuna pruriens, Piper longum, Shatavari, Guggul, Cinchona.

**B.** Aromatic crops: Palmarosa, lemongrass, citronella, vetiver, mentha, patchouli, geranium, Artemisia (Davana), lavender, *Ocimum* sp., sandal wood. Rosemary.

#### Practicals

- Description of botanical and varietal features;
- Nursery techniques;
- Lay out and planting;
- Manuring practices;
- Maturity standards;
- Harvesting;
- Primary processing;
- Extraction of oils;
- Herbarium preparation;
- Project preparation for establishing herbal gardens;
- GAP in medicinal and aromatic crops;
- GMP in medicinal and aromatic crops;
- Exposure visits to institutes, herbal gardens and industries.

#### **Suggested References**

- Atal CK and Kapur BM. 1982. Cultivation and Utilization of Medicinal Plants. RRL, CSIR, Jammu.
- Barche S. 2016. Production technology of spices, aromatic, medicinal and plantation crops. New India Publishing Agency, New Delhi.
- Das K. 2013. Essential oils and their applications. New India Publishing Agency, New Delhi
- Farooqi AA and Sriram AH. 2000. *Cultivation Practices for Medicinal and Aromatic Crops* Orient Longman Publ.
- Farooqi AA, Khan MM and Vasundhara M. 2001. Production Technology of Medicinal and Aromatic Crops. Natural Remedies Pvt. Ltd.
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- Khan IA and Khanum A. 2001. *Role of Biotechnology in Medicinal and Aromatic Plants*. Vol. IX. Vikaaz Publ.
- Kurian A and Asha Sankar M. 2007. *Medicinal Plants*. Horticulture Science Series, New India Publ. Agency.
- Panda H. 2002. Medicinal Plants Cultivation and their Uses. Asia Pacific Business Press.
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- Ponnuswami et al. 2018. Medicinal Herbs and Herbal Cure. Narendra Publishing House, New Delhi.
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- Ramawat KG and Merillon JM. 2003. *BioTechnology Secondary Metabolites*. Oxford and IBH.
- Shankar SJ. 2018. Comprehensive post harvest technology of flowers, medicinal and aromatic plants. Narendra Publishing House, New Delhi.
- Skaria PB, Samuel M, Gracy Mathew, Ancy Joseph, Ragina Joseph. 2007. Aromatic Plants.New India Publ. Agency.

- Block 1: Genetic diversity
- Unit I: Species and cultivar diversity: Floral and reproductive biology, cytogenetics, male sterility, incompatibility, wild and cultivated species, popular cultivars.
- Unit II: Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm.
- Block 2: Crop improvement
- Unit I: Breeding objectives: Breeding objectives/ goals on the basis of yield, quality, stress tolerance, adaptation.
- Unit II: Breeding methods: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses.
- Block 3: Breeding achievements and future thrusts
- Unit I: Breeding achievements: Breeding achievements in terms of released varieties, parentage, salient features.
- Unit II: Future thrusts: Molecular breeding and biotechnological approaches, markerassisted selection, bioinformatics, breeding for climate resilience

Crops

- A. Plantation crops: Coconut, Arecanut, Cashew, Cocoa, Rubber, Oil palm, Coffee, Tea, Palmyrah.
- **B.** Spice crops: Black pepper, small and Ginger, Turmeric, Fenugreek, Coriander, Fennel, Cumin, Ajwain, Garlic, Nutmeg, Cinnamon, Clove, Tamarind,

#### Practicals

- Characterization and evaluation of germplasm;
- Floral biology, anthesis; pollen behaviour, fruit set;
- Practices in hybridization, selfing and crossing techniques;
- Polyploidy breeding;
- Mutation breeding;
- Induction of somaclonal variation and screening the variants;
- Evaluation of biometrical traits and quality traits;
- Salient features of improved varieties and cultivars;
- Screening for biotic and abiotic stresses;
- Bioinformatics;
- Exposure visits to research institutes for plantation and spice crops.

#### **Suggested References**

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

Anonymous. 1985. Rubber and its Cultivation. The Rubber Board of India.

- Chadha KL, Ravindran PN and Sahijram L. 2000. *Biotechnology in Horticultural and Plantation Crops*. Malhotra Publ. House.
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- *E-manual* on Advances in Cashew Production Technology. ICAR –Directorate of Cashew Research, Puttur –574 202, DK, Karnataka

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Kumar N. 2017. Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants.CBS Publishers.

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- Panda H. 2016. The Complete Book on Cultivation and Manufacture of Tea (2nd Revised Edition). Asia Pacific Business Press Inc.
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- Sera T, Soccol CR, Pandey A, Roussos S. Coffee Biotechnology and Quality. Springer, Dordrecht.
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PSM 505 Breeding of Medicinal and Aromatic Crops	1+1
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#### Theory

Block 1: Genetic diversity

- Unit 1: Species and cultivar diversity: Floral and reproductive biology, cytogenetics, male sterility, incompatibility, wild and cultivated species, popular cultivars.
- Unit 2: Germplasm evaluation: Survey, collection, conservation and evaluation of germplasm, IPR issues.

Block 2: Crop improvement

- Unit 1: Breeding objectives: Breeding problems in medicinal and aromatic crops. Genetics of active principles, breeding objectives/ goals on the basis of yield, quality, stress tolerance, adaptation.
- Unit 2: Breeding methods: Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploidy breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses.

Block 3:

Unit 1: Breeding achievements: Breeding achievements in terms of released varieties, parentage, salient features.

Unit 2: Future thrusts: Molecular breeding and biotechnological approaches, markerassisted 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, Rauvolfia serpentina, Piper longum,
- **B.** Aromatic crops: Mint, Scented geranium, patchouli, lemon grass, palmarosa, citronella, vetiver, Artemisia Davana, ocimum, *Kaempferia*, Rosemary.

## Practicals

- Description of botanical features;
- Cataloguing of cultivars, varieties and species in medicinal and aromatic crops;
- Floral biology;
- Selfing and crossing;
- Evaluation of hybrid progenies;
- Induction of economic mutants;
- High alkaloid and high essential oil mutants;
- Evolution of mutants through physical and chemical mutagens;
- Introduction of polyploidy;
- Screening of plants for biotic and abiotic stress;
- In-vitro breeding in medicinal and aromatic crops.

#### **Suggested References**

- Chadha KL and Gupta, R. 1995. Advances in Horticulture. Vol. XI. Malhotra Publ. House. Farooqi AA, Khan MM and Vasundhara M. 2001. Production Technology of Medicinal andAromatic Crops. Natural Remedies Pvt. Ltd.
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Jain SK. 2000. Medicinal Plants. National Book Trust.

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

PSM 506	Systematics of Plantation and Spice Crops	1+1
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#### Theory

Block 1: Origin and evolution

Unit I: Centre of origin: Centre of origin, distribution, phylogeny. taxonomical status

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

- Genus, species and cultivar features of various plantation and spice crops;
- Characterization based on descriptors;
- Characterization based on DUS guidelines;
- Study of sex forms and floral biology;
- Study of molecular markers;
- Exposure visits to national institutes including NBPGR.

# **Suggested References**

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

- Chadha KL and Gupta R. 1995. *Advances in Horticulture*. Vol. XI. Malhotra Publ. House. Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall Publications,
- Diwan AP and Dhakad NK. 1996. *Genetics and Development*. Anmol Publications Private Limited, New Delhi.
- *E-manual* on Advances in Cashew Production Technology. ICAR –Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
- Panda H. 2013. The Complete Book on Cashew. Asia Pacific Business Press Inc.
- Panda H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
- Pillay PNR. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668
- Ponnuswami et al. 2018. Blossom biology of Horticultural crops. Narendra Publishing House, New Delhi
- Ponnuswami et al. 2018. Botany of Horticultural crops. Narendra Publishing House, New Delhi
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- Tamarin RH. 1999. Principles of Genetics. Wm. C. Brown Publishers

Block 1: Origin and evolution

- Unit I: Centre of origin: Centre of origin, distribution, phylogeny, chemotaxonomy.taxonomical status,
- 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,
- 2. Aromatic crops: Lemongrass, Citronella, Palmarosa, Vetiver, Mint, Patcholi, Geranium, Ocimum, Rosemary, Lavender, Eucalyptus, Shatavari, Guggul, Cinchona.

#### Practicals

- Genus, species and cultivar features of various medicinal and aromatic crops;
- Characterization based on descriptors;
- Characterization based on DUS guidelines;
- Study of sex forms and floral biology;
- Study of molecular markers;
- Exposure visits to national institutes including NBPGR.

#### Suggested References

- Birel Shah and Seth AK. 2005. *Text book of Pharmacognosy and Phytochemistry*. CBS Publishers and distributors, New Delhi.
- Charles Burnham. 1993. Discussions in Cytogenetics. Prentice Hall Publications
- Diwan AP and Dhakad NK. 1996. *Genetics and Development*. Anmol Publications Private Limited, New Delhi.
- Farooqi AA, Khan MM and Vasundhara M. 2001. Production Technology of Medicinal and Aromatic Crops. Natural Remedies Pvt. Ltd.
- Gupta RK. 2010. Medicinal and Aromatic plants. CBS publications
- Prajapati ND, Purohit SS, Sharma AK, Kumar T. 2006. A Hand book of Medicinal Plants. Agro Bios (India).
- Ponnuswami et al. 2018. Blossom biology of Horticultural crops. Narendra Publishing House, New Delhi.
- Ponnuswami et al. 2018 Botany of Horticultural crops. Narendra Publishing House, New Delhi

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

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

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

Skaria P Baby et al. 2007. Aromatic Plants. New India Publ. Agency.

Strickberger MW. 2005. *Genetics* (III Ed). Prentice Hall, New Delhi, India Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publishers. Thakur RS, Pauri HS and Hussain A. 1989. *Major Medicinal Plants of India*. CSIR.

PSM 508	Underexploited	Plantation,	Spice,	Medicinal	and	Aromatic	2+0
	Plants						

#### Theory

- Block 1: Importance and status
- Unit I: Importance and Uses: Introduction, importance, economic parts used, traditional uses.
- Unit II: Status and future prospects: Present status, origin, distribution and future prospects of under exploited PSMAs.
- Block 2: Production technology
- Unit I: Propagation and varieties: Propagation and nursery techniques, species varieties.
- Unit II: Agro techniques: Climatic and soil requirements, planting and after care, weed and water management, manuring, plant protection.
- Block 3: Harvest and post harvest management
- Unit I: Harvest indices: Maturity indices, harvesting time, techniques, crop duration.
- Unit II: Post harvest management: Primary processing, extraction and value addition, storage, active ingredients.

Crops

- A. Plantation crops: Wattle, minor species of Areca, Coffea, Hevea
- B. Spice crops: Illicium verum, Myristica malabarica, M. beddomei, Cinnamomum tamala, C. malabatrum, Xanthoxylum sp., Curcuma caesia, C. aromatica, C. zedoaria, C. amada, Anethum graveolense, Hyssopus officinalis, Eringiumfoetidum, Pimpinella anisum, Artocarpus lakoocha.
- C. Medicinal plants: Flacourtia montana, Plectranthus aromaticus, Adhatoda sp. Hemidesmus indicus, Tinospora cordifolia, Gymnema sylvestre, Psoralea corylifolia, Eclipta alba, Aristalochia indica, Morinda citrifolia, Caesalpinia sappan, Terminalia chebula, T. bellerica, Phyllanthus amarus, Strychnos nuxvomica, S. indicum, S. xanthocarpum, Aegle marmelos, Alpinia sp., Hibiscus subdariffa, Anthocephalus kadamba, Costus sp., Kaempferia rotunda, K. parviflora, Picrorrhiza kurroa, Nardostachis jatamansi, Valeriana officinalis, Swertia chiraita, Aconitum sp., Salvia officinalis, Centella asiatica, Bixa orellana, Bacopa monnieri
- D. Aromatic plants: Bursera sp., Commiphora wightii, Ocimum kilimandjaricum, Melaleuca, Michaelia champaka, Rosa damascena, Cananga odorata, marjoram, chamomile

#### **Suggested References**

- Atal CK and Kapur BM. *Cultivation and Utilization of Aromatic plants*. R.R.L. Jammu Barche Swati. 2016. *Production technology of spices, aromatic, medicinal and plantation crops*. New India Publishing Agency, New Delhi
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- Nybe EV, Mini Raj N and Peter KV. 2007. *Spices*. Horticulture Science Series, New India Publ.Agency.
- Peter KV. *Under exploited and underutilized Horticulture crops*. Volume I-IV. New India Publication Agency.
- Ponnuswami et al. 2018. Blossom biology of Horticultural crops. Narendra Publishing House, New Delhi.
- Ponnuswami et al. 2018. Botany of Horticultural crops. Narendra Publishing House, New Delhi
- Ponnuswami et al. 2018. Medicinal Herbs and Herbal Cure. Narendra Publishing House, New Delhi
- Sharangi AB and Datta S. 2015. Value Addition of Horticultural crops: Recent trends and Future directions. SPRINGER; ISBN: 978-81-322-2261-3.
- Sharangi AB, Bhutia PH, Chandani Raj A and Sreenivas M. 2018. Underexploited spice crops: Present status, agrotechnology and future research directions. Apple Academic Press (Taylor and Francis Group), Waretown, NJ, USA, p.326.
- Sivarajan VV and Balachandran I. 1994. *Ayurvedic Drugs and their Plant Sources*. Oxford and IBH.

# PSM 509 Growth and Development of Plantation, Spice, Medicinal and 2+1 Aromatic Crops.

#### Theory

- Block 1: Growth, development, assimilate partitioning and plant bio regulators
- Unit I: Stages of growth: Growth and development, definitions, components, photosynthetic productivity, different stages of growth, growth curves, growth analysis, morphogenesis in PSMAs.
- Unit II: Growth pattern: in annual, semi-perennial and perennial crops, growth dimorphism, environmental impact on growth and development: effect of light, temperature, photoperiod.
- Unit III: Assimilate partitioning: Assimilate partitioning during growth and development, influence of water and mineral nutrition.
- Block 2: Canopy management
- Unit I: Canopy management: Canopy management for conventional and high density planting pruning, training, chemicals, crop regulation for year round and off season production in PSMAs.

Unit II: Plant bio regulators: plant bio regulators- auxins, gibberellins,

cytokinins, ethylene, inhibitors and retardants, basic functions, biosynthesis and role in crop growth and development.

Block 3:

Unit I: Vegetative phase: Developmental physiology and biochemistry during dormancy, bud break, juvenility.

Unit II: Flowering and fruit set

- Physiology of flowering, photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism, pollination, fertilisation, fruit set, fruit drop, fruit growth, ripening, seed development in PSMAs.
- Unit III: Growth and development process during stress: Growth and development process during stress, production of secondary metabolites, molecular and genetic approaches in growth and development.

#### Practicals

- Dormancy mechanisms in seeds, seed rhizomes;
- Techniques of growth analysis;
- Evaluation of photosynthetic efficiency under different environments;
- Technologies for crop regulation in cashew, coffee, cocoa, etc.;

- Root shoot studies, flower thinning, fruit thinning;
- Crop regulation for year round production;
- Use of growth regulators in PSMA crops.

## **Suggested References**

- Afoakwa EO. 2016. Cocoa Production and Processing Technology. CRC Press
- Buchanan BW. Gruiessam and Jones, R. 2002. *Biochemistry and Molecular Biology of Plants*. John Wiley and Sons.
- *E- manual* on Advances in Cashew Production Technology. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
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- Panda H. 2016. *The Complete Book on Cultivation and Manufacture of Tea* (2nd Revised Edition). Asia Pacific Business Press Inc.
- Pillay PNR. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668
- Ravindran PN. 2000. Black pepper, Piper nigrum. CRC press
- Ravindran PN. 2002. Cardamom, the genus Elettaria. CRC press
- Ravindran PN. 2003. Cinnamon and cassia. CRC press
- Ravindran PN. 2004. Ginger, the genus Zingiber. CRC press
- Ravindran PN. 2007. Turmeric, the genus curcuma. CRC press
- Roberts JS Downs and P Parker. 2002. *Plant Growth Development*. In: *Plants* (L. Ridge, Ed.), pp. 221-274, Oxford University Press
- Salisbur FB and Ross CW. 1992. Plant Physiology. 4th Ed. Wadsworth Publ.
- Sera T, Soccol CR, Pandey A. and Roussos S. Coffee Biotechnology and Quality. Springer, Dordrecht.
- Sethuraj MR and Mathew NT. 1992. Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science). Elsevier Science.

PSM 510	Biochemistry of Plantation, Spices, Medicinal and Aromatic	2+1
	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 PSMAs.
- Block 2: Value addition
- Unit I: Value added products: Fixed oils, essential oils, dyes, oleoresins, aroma chemicals and other value added products, their content, storage, medicinal and pharmacological properties, use in the food, flavour perfumery and pharmaceutical industries.
- Unit II: Quality standards: Quality standards of raw materials and finished products.
- Block 3: Extraction techniques

UnitI: Extraction methods: Basic and advanced extraction techniques in PSMAs-Soxhlet, SCFE, Membrane extraction. Chemical characterization-HPTLC, GCMS, LCMS, NMR.

Unit II: Plant tissue culture: Plant tissue cultures in the industrial production of bioactive plant metabolites. Cell suspension culture systems for large scale

culturing of plant cells and production of secondary metabolites. Advantages of cell culture over conventional extraction techniques.

#### Practicals

- Biochemical characterisation;
- Detection of adulterants and substitutes;
- Extraction and quantification of secondary metabolites;
- Chromatographic separation of the products;
- Quality assurance;
- Testing the product;
- Exposure visit to leading industries;
- Assessment of antimicrobial properties;
- In-vitro production of secondary metabolites.

## **Suggested References**

- Afoakwa EO. 2016. Cocoa Production and Processing Technology. CRC Press.
- Daniel M and Mammen D. 2016. *Analytical methods for medicinal plants and economic botany*. Scientific publishers.
- Das K. 2013. Essential oils and their applications. New India Publishing Agency, New Delhi.
- *E-manual* on Advances in Cashew Production Technology. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka.
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- Orhan I. 2012. *Biotechnological Production of Plant Secondary Metabolites*. Bentham Science Publishers.
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- Panda H. 2016. The Complete Book on Cultivation and Manufacture of Tea (2nd Revised Edition). Asia Pacific Business Press Inc.
- Parimelzhagan T. 2013. *Turning plants into medicines: Novel approaches*. New India Publishing Agency, New Delhi.
- Pillay PNR. 1980. *Handbook of Natural Rubber Production in India*. Rubber Research Institute, Kottayam. pp.668.
- Ponnuswami et al. 2018 Medicinal Herbs and herbal cure. Narendra Publishing House, New Delhi.
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- Raju R Wadekar. 2015. Pharmacognosy and phytochemistry, Event publishing house.
- Ramawat KG. 2007. *Biotechnology: secondary metabolites: plants and microbes*. Science Publishers.
- Ranjal Kandall. *Bioactive compounds and genomic study of medicinal plants*. LAMBERT Academic Publishing.
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Shukla YM. 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 C. 2018. Antimicrobial properties of Medicinal plants. Narendra Publishing House, New Delhi.
- Trivedi C. 2004. Herbal drugs and biotechnology. Pointer Publishers.
- Waghulkar VM. 2012. *Quality assurance techniques in pharmaceuticals*. New India Publishing Agency, New Delhi.

# PSM 511Biodiversity and Conservation of Plantation, Spices Medicinal2+1and Aromatic Crops2

#### 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**

- Collection and identification of different plantation, spice, medicinal and aromatic plants from natural sources;
- Preparation of herbarium;
- Botanical and phyto-chemical grouping of PSMAs;
- Classification of PSMAs based on plant parts used;
- Documentation of germplasm;
- Maintenance of passport data and other records;
- Field explorations;
- Detection of adulterants and substitutes in PSMAs;
- Ethno botanical studies in tribal areas;
- Planning and layout of herbal gardens;
- Exposure visits to herbaria, herbal gardens and important organisations engaged in collection and utilization of PSMAs.

# **Suggested References**

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

- Choudhari AB. Megadiversity Conservation: Flora, Fauna and Medicinal Plants of India's hot spots.
- Devi AR, Sharangi AB, Acharya SK and Mishra GC. 2017. Coriander in Eastern India: The landraces and genetic diversity. Krishi Sanskriti Publications. New Delhi. ISBN: 978-93- 85822-48-3.
- *E- manual* on Advances in Cashew Production Technology. ICAR -Directorate of Cashew Research, Puttur –574 202, DK, Karnataka
- Kassahun Beemnet, Jemal Omar Sherif, TessemaTsion, Abate Solomon. 2009. Production, Processing and utilization of Aromatic Plants. EIAR.
- Khan JB and Singh GP. 2012. Biodiversity Management and Conservation LAMBERT
- Negi SS. Biodiversity of India and its Conservation.
- Panda H. 2002. Medicinal Plants Cultivation and their Uses. Asia Pacific Business Press.
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- 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
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- Pullaiah T. 2011. Biodiversity in India Vol.5. Daya Publishing house
- Rajak RC and Rai MK. Herbal Medicines, Biodiversity and Conservation strategies. IBH.

Ramakrishnan N. 2018. Biodiversity in Indian Scenario. Daya publishing house.

- Sera T, Soccol CR, Pandey A, Roussos S. Coffee Biotechnology and Quality. Springer, Dordrecht.
- Sethuraj MR and Mathew NT. 1992. Natural Rubber: Biology, Cultivation and Technology (Developments in Crop Science). Elsevier Science.
- Thirugnanakumar. 2018. *Genetic diversity and phenotypic stability in crop plants*. New India Publishing Agency, New Delhi

Trivedi PC. Medicinal Plants: Utilization and Conservation.

## PSM – 512 Processing and Quality Analysis of Medicinal and Dye Plants 1+1

#### Theory

History and development of different extraction methods of active principles of commercial medicinal crops. Handling and processing of different plant materials before extraction. Preparation of plant material for extraction. Study of different methods of extraction of alkaloids, diterpenes and other compounds from different economic parts. Study of preparation of different end products of medicinal plants. Study of different physical and chemical methods in quality analysis active chemical compounds. Role of instrumentation in quality analysis. Principles and practices of different types of chromatograms: paper, thin layer, column, gas–liquid and high performance liquid chromatograph (HPLC). Industrial commercial uses of plant extracts.

#### **Practicals**

Identification of different economic parts and commercial produce. Preparation of plant material for extraction. Study of different extraction methods for plant extracts, like water extraction, solvent extraction, drying and purification. Use of soxhlet method for isolation of extract. Extraction of crude drugs from different medicinal crops. Determination of extractable matter, water and volatile matter, bitterness value, tannins, swelling index in isabgol husk and seeds, etc. Handling of chromatographs, quality analysis of purified compounds for adulteration and other forging matter. Visit to commercial extraction and product development units.

#### **Suggested Referencess**

Atal C.K. and Kapur B.M. Cultivation and Utilization of Medicinal Plants. R.R.L, Jammu. Mukherjee B.M. Standardization of Botanical, Testing and Methods of Extraction of Medicinal Herbs. Volume–1 and 2. Eastern Publication.

Chatwal and Anand, S. Instrumental Methods and Chemicals Analysis. Himalaya Publications.

Anonymous Quality Control methods for Medicinal Plants Material.

W.H.O publication

Introduction, historical background, present status and different uses of edible dyes and bio-pesticidal plants. Origin and distribution, species varieties, economic parts. Soil and climatic requirements, nutrition, water and weed management. Plant protection, harvesting and extraction of active principles in different dye yielding and bio-pesticidal plants like Annatto, Mehandi, Indigo, Indian Maddar, Marigold, Caesalpinia sappan, Pyrethrum, Red sanders, Neem, Sweet flag, Adhatoda, Clerodendron inerme, Vitex nigondu, etc. The chemistry, bioefficacy, toxicity of different bio- pesticidal plants.

## Practicals

Study of botanical characteristics of different species of natural dye and bio-pesticidal plants. Study of propagation and nursery techniques. Study of pests and diseases and their management. Extraction and quantification of edible dyes and biopesticide contents.

## **Suggested Referencess**

- Parkes C. H; 'Creating colour in Yarn: An introduction to natural Dyes', Knitter's Review, 2002–2003.
- http:/fwww.housebarra.com/EP/fep03f03dyes.html; 'Natural dyes', December 22, 2003.
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The Wealth of India, Raw Materials, CSIR, 17, 8, 1990

- Green, C. L., 1995. "Natural Colorants and Dyestuffs", Food and Agriculture Organization of the United Nations, Italy
- Lewin, M. and S. Sello, 1983, "Handbook of Fiber Science and Technology: Chemical Processing of Fiber and Fabrics", Marcel Dekker, NY,

## PSM 514 | Bio-technology of Spices, Plantation, Medicinal and Aromatic Crops | 1+1

#### Theory

Harnessing bio-technology in horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture. Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis. Use of bioreactors and in vitro methods for production of secondary metabolites, suspension culture, nutrition of tissues a nd cells, regeneration of tissues, ex vitro, establishment of tissue cultured plants. Physiology of hardening – hardening and field transfer, organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture and fusion. Construction and identification of somatic hybrids and cybrids, wide hybridization, in vitro pollination and fertilization, haploids, in vitro mutation, artificial seeds, cryopreservation, rapid clonal propagation, genetic engineering in horticulture crops, use of molecular markers. In vitro selection for biotic and abiotic stress, achievements of biotechonolgy in horticultural crops.

#### Practicals

An exposure to low cost, commercial and homestead tissue culture laboratories, media preparation, inoculation of explants for clonal propagation, callus induction and culture, regeneration of platnt-lets from callus, sub-culturing, techniques on anther, ovule, embryo

culture, somaclonal variation, in vitro mutant selection against abiotic stress, protoplast culture, fusion technique, development of protocols for mass multiplication, project development of commercial tissue culture laboratory.

#### **Suggested References**

Singh, B.D., 2007. Biotechnology.

Parthasarathy, V.A., Utpala Parthasarathy and A.Kumar, 2008. Spices Vol 2, Todays and Tomarrows publishers

Bhojwani, S.S.(Eds), 1990. Plant tissue culture. Elsevier science pub

Parthasarathy, V.A, Bose, T.K, Deka, P.C, Das, P, Mitra S.K and Mohandas,

S. 2001. Biotechnology of Horicultural crops New India publ agency.

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

PSM 515	Value Addition, By-product Utilization in Spices, Plantation,	1+1
	Medicinal and Aromatic Crops	

## Thoery

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. Byproduct utilization in plantation crops for coir production, mushroom culture, cocopit, 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). Value addition on aromatic oils and medicinal herbs. 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. Objectives of waste utilization, method of safe disposal of waste material, improvement of soil fertility, improvement of soil tilth and reduction of soil erosion.

## **Practicals**

Study on product diversification in plantation and spice crops. (e.g. Coconut : fresh nuts, tender nuts, coconut milk, cream, spray dried coconut milk powder, defatted coconut powder, desiccated coconut, virgin coconut oil, preserved tender coconut water, toddy utilization in jaggary, alcohol, sugar, vinegar etc, coconut based dairy products– chips, biscuits, Nata–de–coes, coconut shell products, coir and its utilization etc)Study of processing and by product utilization of different spices and plantation, medicinal and aromatic crops. Methods of byproduct utilization in plantation crops for coir production, mushroom culture, coco–pit, honey bee keeping, Oil cake production and utilization, vermi–composting etc, Study of processing of medicinal plants, their drying and storage. Extraction and identification of active ingredients from different spices and herbs using TLC, HPLC, GCfCG–MS technology. Study

of waste material utilization in aromatic crops such as davana, lemon grass, vetiver, palmarosa, patchouli, rosemary, java citronella, etc. Usage of spent material in agarbatti manufacturing, Value added products from spices and plantation crops.

## **Suggested References**

Chadha KL et al(Eds) 1993–95. Advances in Horticulture. Vol IX. Plantation crops and spices. Malhotra publishing house, New Delhi.

Peter, K.V.(Ed). 2001. Handbook of Herbs and spices. Vol I-III. Wood Head publ co. UK &CRC, USA

Mandal, RC, 1996. Coconut production and Processing technology. Agro. Bot.

Mandal, RC, 1997. Cashew: Production and processing technology. Agro Bot.

# PSM – 516 Cropping Systems in Spices, Plantation, Medicinal and 1+1 Aromatic Crops

## Theory

System approach in the cultivation of spices, plantation, medicinal and aromatic crops. Definition and importance of natural and physical resources in the cultivation of crops and their management in spices, plantation, medicinal and aromatic crops based cropping system. Multiple cropping, intercropping, sequential cropping, alley cropping, mixed cropping, multistoried cropping, in spices, plantation, medicinal and aromatic crop based cropping system. Advantages, interactions and associated constraints, complimentary interactions competitions - allelopathic effect, role of non monetary inputs and low cost technologies input use efficiency, land use indices including Crop intensity index (CII) and Land Equivalent Ration (LER) in different of spices, plantation, medicinal and aromatic crop based cropping systems. Assessment of viability of a cropping system, yield advantage, economic evaluation of cropping systems- Important plantation and spice based cropping systems prevailing in South India including areca nut and coconut based multi-storied systems. Medicinal and aromatic crops based cropping systems. Mixed farming – Integrated farming systems (IFS), – choice of enterprises interaction among enterprises- advantages of different IFS models for different situation for spices, plantation, medicinal and aromatic crop based integrated farming system.

#### Practicals

Study on the efficiency of utilization of natural resources (soil *f* land and solar radiation) under different plantation based spice gardens and cropping systems. Studies on the management of nutrition and water under different plantation *f* spices *f* medicinal *f* aromatic crop based cropping systems. Studies on integrated management of pest and diseases under different plantation *f* spices *f* medicinal *f* aromatic crop based cropping systems.

#### **Suggested References**

Dwivedi, A.P. 1992, Agroforestry Principles and practices Oxford & IBH
Gangopadhyaya, A., 2007, Crop Production systems and Management. Gene Tech Books
Palaniyappan, S.P. and Sivaraman, K. 1996, Cropping systems in the tropics: Principles and Management, New Age Publishers Panda, S.C., 2003, Cropping and Farming systems, Agrobios

# Sen,N. L., Dadheech, R.C. Dashora, L.K. and Rawat, T.S. 2004 Manual of Agroforestry and Social Forestry, Agrotech Publ.

PSM - 517	Extraction, Storage and Quality Analysis of Essential Oils	1+1
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#### Theory

History and development of different extraction methods. Handling and processing of different plant materials before extraction. Preparation of plant material for packaging and extraction. Principles and practices of different methods of essential oil extraction– distillation, solvent extraction, maceration, enfleurage, expression method and super critical fluid extraction (SCFE), etc. Study of preparation of different end products of aromatic plants. Study of different physical and chemical methods in quality analysis of essential oils. Role of instrumentation in quality analysis. Principles and practices of different types of chromatograms: paper, thin layer, column, gas, gas–liquid. Storage of essential oils. Principles of sensory evaluation of essential oils. Industrial uses of essential oils. Study of adulterating materials and their identification.

## **Practicals**

Identification of different economic parts. Preparation of plant material for extraction. Study of different extraction methods for essential oils viz. hydro and steam distillation, solvent extraction and SCFE methods. Handling of chromatographs, quality analysis of essential oils through physico- chemical methods. Determination of density, refractive index, specific gravity, optical rotation, polarity, acid value, phenol value, alcohol value, ester value, etc and sensory evaluation of essential oils. Storage studies in essential oils. Visit to commercial extraction and product development units.

#### **Suggested References**

Guenther E. The essential oils. Volume 1–6.

Atal C.K. and Kapur B.M. Cultivation and Utilization of Medicinal Plants, R.R.L, Jammu Mahendra, Extraction methods.

Chatwal and Anand S. Instrumental methods and chemical analysis. Himalaya Publication. Varshney S.C. Mint essential oils by distillation.

Sl.	Course	Course Title	Credit
No.	No.		Hours
Major	courses (Mini	imum 20 Credits)	
1	PHM 501*	Postharvest Management of Horticultural Produce	2+1
2	PHM 502*	Postharvest Physiology and Biochemistry of Perishables	2+1
3	PHM 503	Packaging and Storage of Fresh and Processed Horticultural	2+1
		Produce	
4	PHM 504*	Food Additives in Horticultural Products	1+1
5	PHM 505*	Principles and Methods of Fruit and Vegetable Preservation	2+1
6	PHM 506	Laboratory Techniques in Postharvest Management	1+2
7	PHM 507*	Processing of Horticultural Produce	2+2
8	PHM 508	Quality Assurance, Safety and Sensory Evaluation of Fresh and	2+1
		Processed Horncultural Produce	•
9	PHM 509	Functional Foods from Horticultural Produce	2+0
10	PHM 510	Marketing and Entrepreneurship in Postharvest Horticulture	1+1
11	PHM 511	Preservation by Fermentation and Dehydration	1+1
12	PHM 512	Preservation by Canning and Freezing	1+1
13	PHM 513	Processing Technology for Spices and Plantation Crops	1+1
14	PHM 514	Postharvest Handling and Processing of Ornamental, Medicinal and Aromatic Plants	1+1
15	PHM 515	In-plant Training and Management of Waste from Horticultural Processing Industries	1+1
16	PHM 516	Process Engineering in Horticultural Crops	1+1
17	PHM 517	Safety in Horticulture Food Chain	2+0
18	PHM 571	Qualifying Examination	0+2
19	PHM 581	Seminar-I	0+1
20	PHM 582	Seminar-II	0+1
21	PHM 591	Research	0+27

\* Compulsory among major courses

- 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 Horticultural Sciences–Post-harvest Management in roots and tubers. Prepackage Operation: Preecooling, washing, sorting, grading of horticultural perishables for local markets and export. Postharvest handling of spices, plantation crops, medicinal and aromatic plants.Equipments for washing, sizing, grading.
- Unit IV: Pre and Postharvest treatments for extending storage life/ vase life. VHT, irradiation treatment, skin coating, degreening, etc. Pre-packaging, Packaging techniques for local market and export. Standardsand specifications for fresh produce.
- Unit V: Postharvest handling system for horticulture crops of regional importance. Principles of transport, modes of transportation, types of vehicles and transit requirements for different horticultural produce. Marketing: Factors influencing marketing of perishable crops, marketing systems and organizations.

## 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 vaselife of cut flowers by use of chemicals and growth regulators;
- Control of sprouting of potato and onion by using growth regulators;
- Study of modern harvesting, sorting and grading equipments;
- Study of effect of pre-cooling on shelf-life and quality of fresh fruits, vegetables and flowers;
- Visit to packaging centers;
- Visit to local markets, cooperative organizations, super markets dealing with marketing of Perishables.

#### **Suggested References**

- Bhattacharjee SK and Dee LC. 2005. Postharvest technology of flowers and ornamental plants. Pointer publishers, Jaipur.
- Chattopadhyay SK. 2007. Handling, transportation and storage of fruits and vegetables. Gene-Tech books, New Delhi.
- FAO. 2007. Handing and Preservation of Fruits and Vegetables by Combined methods for Rural Areas-Technical Manual. FAO Agr.Ser.Bull., 149.
- Kader AA. 1992. Postharvest technology of horticultural crops. 2nd ed university of California.
- Paliyath G, Murr DP, Handa AK and Lurie S. 2008. Postharvest Biology and Technology of Fruits, Vegetables and Flowers, Wiley-Blackwell, ISBN: 9780813804088.
- Pruthi JS. 2001 (Reprint). Major spices of India crop management and Postharvest technology. ICAR, NewDelhi
- Stawley J Kays. 1998. Postharvest physiology of perishable plant products. CBS publishers.
- Sudheer KP, Indira V. 2007. Postharvest Technology of Horticultural Crops, Peter K.V. (Ed.), New India Publishing Agency, ISBN 9788189422431.

- Sunil Pareek (Ed.) 2016. Postharvest Ripening Physiology of Crops, CRC Press, ISBN 9781498703802.
- Thompson AK. (Ed.) 2014. Fruit and Vegetables: Harvesting, Handling and Storage (Vol. 1 & 2) Blackwell Publishing Ltd, Oxford, UK. ISBN: 9781118654040.
- Verma LR and Joshi VK. 2000. Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management. Indus Publishing Company, New Delhi, India.ISBN 8173871086.
- Wills RBH and Golding J. 2016. Postharvest: an introduction to the physiology and handling of fruit and vegetables, CABI Publishing, ISBN 9781786391483.
- Wills RBH and Golding J. 2017. Advances in Postharvest Fruit and Vegetable Technology, CRC Press, ISBN 9781138894051.

PHM 502	Postharvest Physiology and Biochemistry of Perishables	2+1	
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Block 1: Biochemistry of perishables

- Unit I: Introduction, biochemical structure and composition of fruits, vegetablesand ornamentals.
- Unit II: Biochemical changes during development and ripening. StructuralDeterioration of the Produce-cell wall degradation, change in membranelipid.: Biosynthesis of ethylene and its regulation. Ethylene action andripening processes, its perception-action and regulation.
- Block 2: Postharvest physiology of perishables
- Unit I: Determining maturity and maturity indices. Ripening processes: eventsof ripening and factors affecting them.
- Unit II: Physiology of preharvest and postharvest; factors affecting shelf-lifeand quality of fruits, vegetables and ornamentals.
- Unit III: Respiration: respiratory climacteric, its significance. Transpiration andwater stress during postharvest. Postharvest oxidative stress: activeoxygen species, AOS generation, physiological effects on horticulturalcommodity, control of oxidative injury.

## 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.

## Suggested References

Chadha KL and Pal RK. 2015. *Managing postharvest quality and losses in horticultural crops*. Vol-1: General Issues, 1-231p Astral International (P) Ltd., New Delhi

Chadha KL and Pal RK. 2015. *Managing postharvest quality and losses in horticultural crops*. Vol-2: Fruit Crops, 253-561p Astral International (P) Ltd., New Delhi

- Chadha KL and Pal RK. (2015) *Managing postharvest quality and losses in horticultural crops*. Vol-3: Vegetables, Flowers and Plantation Crops, 581-727p Astral International (P) Ltd., New Delhi
- Hodges DM. 2003. Postharvest Oxidative Stress in Horticultural Crops, 1st Edition, ISBN 9781560229636
- Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest Biology and Technology of Fruits, Vegetables and Flowers*, Wiley-Blackwell, ISBN: 9780813804088.
- Sunil Pareek (Ed.) 2016. Postharvest Ripening Physiology of Crops, CRC Press, ISBN 9781498703802.
- Thompson AK. 1995. Post harvest Technology of fruits and vegetables. Blackwell Sciences
- Verma LR and Joshi VK. 2000. Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management. Indus Publishing Company, New Delhi, India.ISBN 8173871086.
- Wills RBH and Golding J. 2017. Advances in Postharvest Fruit and Vegetable Technology, CRC Press, ISBN 9781138894051.
- Wills RBH and Golding J. 2016. *Postharvest: an introduction to the physiology and handling of fruit and vegetables*, CABI Publishing, ISBN 9781786391483.

PHM 503	Packaging	and	Storage	of	Fresh	and	Processed	Horticultural	2+1
	Produce								

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 storageprinciple, 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, formfill-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.

## **Suggested References**

Ahvenainen R. 2003. Novel Food Packaging Techniques, CRC Press, ISBN 0849317894.

Ahvenainen R. 2001. Novel Food Packaging Techniques.CRC.

- Burg SP (Ed.). 2004. Postharvest physiology and hypobaric storage of fresh produce, CABI Publishing, ISBN 0851998011.
- Chattopadhya SK. 2007. Handling, transportation and storage of fruits and vegetables. Gene-Tech books, New Delhi.
- Chandra GopalaRao. 2015. Engineering for Storage of Fruits and Vegetables; Academic Press, 1st Edition.
- Coles R, McDowell D and Kirwan MJ. (Eds.). 2003. Food Packaging Technology, Blackwell Publishing, ISBN 1841272213.
- Mahadevaiah M and Gowramma RV. 1996. Food packaging materials. Tata McGraw Hill.Painy FA. 1992. A handbook of food packaging. Blackie Academic.
- Pantastico B. 1975. Postharvest Physiology, Handling and Utilization of Tropical and Subtropical Fruits and Vegetables. AVI Publ.
- Robertson GL. (Ed.). 2010. Food packaging and shelf life: a Practicalsguide CRC Press, ISBN 9781420078442.
- Thompson AK. 2010. Controlled atmosphere storage of fruits and vegetables (2nd Edition), CABI International, ISBN 9781845936464.
- Wilson CL. (Ed.). 2007. Intelligent and active packaging for fruits and vegetables, CRC Press, ISBN 9780849391668.

Unit 1:Importance of preservation of horticultural produce by food additives and preservatives. Principles and methods of preservation by use of sugar, salt, spices, essential oils, vinegar and chemical preservatives.Food additives- definitions, classification and functions, Preservatives - mode of action of chemical preservatives; antioxidants, colours and flavours(synthetic and natural}, emulsifiers, sequesterants, humectants, hydrocolloids, sweeteners, acidulants, buffering salts, anticaking agents, clarifying agents *etc.* chemistry, uses in horticulture foods and functions in formulations; indirect food additives; toxicological evaluation of food additives.

Unit2:FlavourtechnologyTypesofflavours,flavoursgeneratedduringprocessingreactionflavours,flavourcomposites,stabilityofflavoursduringfood processing,flavouremulsions;essentialoilsandoleoresins;authentication of flavours*etc*.

- Unit 3: Usesofenzymesinextractionofjuices.Pecticsubstancesandtheirroleas jellifying agents. Carbonated and non-carbonated fruit beverages - their preparation and preservation.
- Unit 4: Proteins, starches and lipids as functional ingredient; functional properties and applications in horticultural foods.
- Unit 5: Studyofspoilagesinpreservedproducts.Safetyoffoodadditives.

## Practicals

- Extraction of fruit and vegetable juices using enzymes.
- clarification, preservation and storage of juices.
- Preparation and preservation of RTS, cordial, squash, concentrate and syrup.
- Preparation and preservation of jam, jelly, marmalade
- Preparation and preservation of ketchup, sauce, chutneys,
- Preparation and preservation of pickles,
- preservescandies, crystallized products, gulkand.
- Use of additives and preservatives in these products.
- Preparation and preservation of carbonated beverages.
- Sensory evaluation and quality analysis of preserved products.
- Study of spoilagesin preserved products. Visit to processing factories.

#### **Suggested Referencess**

- Branen AL, Oavidson PM and Salminen S. 2001. Food additives, 2nd Ed. revisedandexpandededitedbyA.LarryBranenP.MichaelDavidsonSeppoSalminen and John H. Thorngate II Marcel Dekker, Inc.
- Gerorge AB. 1996. Encyclopedia of Food and Color Additives. Vol. III. CRC Press.
- GerorgeAB.2004.Fenaroli'sHandbookofFlavourIngredients.5thEd.CRC Press.
- Madhavi DL, Deshpande SS and Salunkhe DK. 1996.Food Antioxidants Technological, Toxicological and Health Perspective. Marcel Dekker.
- MortonIDandMacleodAJ.1990. Food Flavours.PartA,BC.Elsevier.Methods of analysis of food components and additives edited by SemithOtles published by CRC press Taylor and Francis Group.

NagodawithanaTandReedG.1993.Enzymesinfoodprocessing.Academic Press.

NakaiSandModlerHW.2000.FoodProteins-ProcessingApplications.WileyVCH.

NicholasJ.RusselandGrahameW.Gould.2003.FoodPreservatives.Springer

NormanW.DesrosierandJamesN.Desrosier.1987.Thetechnologyoffood preservation. CBS publishers and Distribution.

StephenAM.(Ed. }.2006.FoodPolysaccharidesandTheirApplications. Marcel Dekker.

Udhal Singh Meena and Suresh Kumar P. 2005. Glimpses of post harvestmanagement. New Vishal publ. New Delhi.

WhitehurstR.andLawryB.2002.Enzymesinfoodtechnology.Blackwell.

PHM 505	Principles and Methods of Fruit and Vegetable Preservation	2+1	
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## 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

- List and cost of equipment, utensils, and additives required for small scale processing industry;
- Chemical analysis for nutritive value of fresh and processed fruits and vegetables;
- Preparation and preservation of fruit based beverages and blended products from fruits and vegetables;
- Evaluation of pectin grade; preparation and quality evaluation of fruit jam;
- Preparation of papain;
- Blanching and its effects on enzyme;
- Preparation of dehydrated vegetables;
- Study of different types of spoilages in fresh as well as processed horticultural produce;
- Study of biochemical changes and enzymes associated with spoilage;
- Sensory evaluation of fresh and processed fruits and vegetables;
- Visit to processing units

#### **Suggested References**

- Barret DM, Somogyi LP and Ramaswamy H. Eds. 2005. Processing Fruits: Science and Technology (2nd Edition), CRC Press, ISBN 9780849314780.
- FAO. 2007. Handling and Preservation of Fruits and Vegetables by Combined Methods for Rural Areas- Technical Manual. FAO Agricultural Services Bulletin 149.
- Fellows PJ. 2009. Food Processing Technology: Principles and Practice (3rd Edition), Woodhead Publishing, ISBN 9781845692162.
- Lal G, Siddappa GS and Tandon GL. 1998.Preservation of Fruits and Vegetables. ICAR, ISBN 9788171640904.
- Ramaswamy H and Marcotte M. 2006. Food Processing: Principles and Applications. Taylor & Francis.
- Salunkhe DK and Kadam SS. 1995. Handbook of Fruit Science and Technology:Production,Composition and Processing. Marcel Dekker.
- Srivastava RP and Kumar S. 2014. Fruit and Vegetable Preservation: Principles and Practices(3rd Edition), CBS Publishing, ISBN 9788123924373.
- Verma LR and Joshi VK. 2000. Postharvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management. Indus Publishing Company, New Delhi, India. ISBN 8173871086.

PHM 506	Laboratory Techniques in Postharvest Management	1+2

#### 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.

#### Practicals

- Sample preparation for quality analysis. Energy calculation, sample calculations;
- Texture analysis, Rheology of different foods;
- Instrumental colour analysis;
- Sensory evaluation and microbiological examinations of fresh and processed products;
- Estimation of tannin/ phytic acid by spectrometric method;
- Moisture and fat analysis by NIR spectroscopy;
- Separation and identification of sugars in fruit juices;
- Separation and identification of carotenoids by column chromatography;
- Estimation of respiration in fruits and vegetables;
- Flavour profile in essential oils using GC;

- Identification and determination of organic acids by HPLC;
- Capsaicin content and Scoville Heat Units in chillies;
- Heavy metal analysis using atomic absorption spectrometry;
- Residue analysis.

## **Suggested References**

Lundanes E., Reubsaet L and Greibrokk T. 2013. *Chromatography: Basic Principles, Sample Preparations and Related Methods*, ISBN-13: 978-3527336203, Wiley VCH

Mark F Vitha. 2016. Chromatography: Principles and Instrumentation. John Wiley & Sons, ISBN 9781119270881

Suzanne NS. 2010. Introduction to Food Analysis, ISBN 978-1-4419-1478-1, Springer.

Ranganna S. 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Tata McGraw-Hill ISBN 9780074518519.

SemihOtles (Ed). 2016. Methods of Analysis of Food Components and Additives (Chemical and Functional Properties of Food Components) CRC Press, ISBN-13:978-1138199149,

PHM 507	Processing of Horticultural Produce	2+2
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## Theory

Block1: Importance and Thermal processes

- Unit I: Processing unit- layout and establishment, processing tools. Quality requirement sofraw materials for processing, preparation of rawmaterial, primary processing : grading, sorting, cleaning, washing, peeling, slicingand blanching; minimal processing.
- UnitII: Preparation of various processed products from fruits and vegetables, flowers; role of sugar and pectinin processed products. Freezing of fruits and vegetables. Containers, equipment and technologies in canning.
- Unit III: Juice extractions, clarification and preservation, recent advances injuice processing technology, application of membrane technology inprocessing of juices, preparation of fruit beverages and juice concentrate. Sensory evaluation.

Block2: Processingequipment and enzyme kinetics

UnitI: 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 andthermal properties of horticultural commodities;
- Thermal process calculations;
- Particle size analysis, Storage structured esign;
- Numerical problems freezing,drying,conveyingandcalculationspertainingtotextureandRheology;
- Handlingofheatingequipment,pulper,juiceextractor,deaerator,juicefilters;
- Processing industries was tetreatment;
- Workingofacanningunit;
- Visittocommercialprocessingunitsandstorageunits.

in

## **Suggested Readings**

- Karel Mand Lund DB.2003. *Physical Principles of Food Preservation* (2ndEdition), CRCPress, ISBN9780824740634.
- Paul Singh R and Heldman DR. 2009.*Introduction to Food Engineering* (4th Edition), Academic Press, ISBN9780123709004.

Rao DG.2010. Fundamentals of Food Engineering, PHI Learning Pvt.Ltd., ISBN 978812033871

# PHM 508Quality Assurances, Safety and Sensory Evaluation of Fresh and<br/>Processed Horticultural Produce2+1

## Theory

- Block1: 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.
- Block2: 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

Analysis for TSS, pH, acidity, sugars, pectic substances, minerals, vitamin C, carotene, alcohol, benzoicacid and SO<sub>2</sub> contents, yeast and microbial examination in processed products;

- Demonstration of measurement of vacuum/ pressure, headspace, filled weight, drained weight, cut-out analysis and chemical additives;
- Moisturecontent, rehydrationratio and enzymatic/ non-enzymatic browning in dehydrated products;

- Analysis of spices for quality parameters. Evaluation of processed products according to FSSAI specification;
- Selection and training of sensory panel;
- Identification of basic taste, odour, texture and colour;
- Detection and threshold tests; Ranking tests for taste, aroma, colour and texture; Sensory evaluation of various horticultural processed products using different scales, scorecards and tests, Hedonic testing;
- Estimation of color and texture; optimizing a product by sensory analysis;
- Studying relationship between objective and subjective methods.

## **Suggested References**

Amerine MA, Pangborn R M and Rosslos EB.1965. Principles of Sensory Evaluation of Food. Academic Press.

- CurtisPA.2005.Guide to Food Lawsand Regulations, Wiley-Blackwell, SBN9780813819464.
  DGHS Manual8: Manual of Methods of Analysis of Foods-Food Additives. Curtis PA.2005. Guide to Food Lawsand Regulations, Wiley-Blackwell, ISBN9780813819464.
  EarlyR.1995.Guide to Quality Management Systems for the Food Industry, Springer, ISBN 9781461358879.
- KempSE, Hollowood Tand HortJ. 2009. *Sensory Evaluation: A Practical Handbook*, Wiley-Black well Publisher, ISBN9781405162104.
- Krammer A and Twigg BA.1973. Quality Control in Food Industry.Vol.I, II. A VI Publ.
- Lawless, HarryT, Heymann and Hilde garde. 2010. Sensory Evaluation of Food: Principles and Practices, Springer, ISBN9781441964885.
- RangannaS.2001.*Hand book of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw - HillISBN9780074518519.
- RangannaS.2001.*Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, Tata McGraw-Hill, ISBN9780074518519.
- *The Food Safety and Standards Act, 2006 along with Rules & Regulations* 2011, Commercial Law Publishers (India) Pvt.Ltd.

111010000   Functional Foods from Horicultural Frond C	PHM 509	Functional Foods from Horticultural Produce	2+0
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#### Theory

Block1: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.
- Block2: Bioactive Compounds
- UnitI: Introduction, Classes of bioactive compounds present in fruits and vegetables. Polyphenols: Phenolic acid, Stilbenes, Flavonoids, Lignin, Coumarin, Tannin, etc.– theirchemistry, source, bio availability, 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 durings to rage and processing.

- Unit II:Mechanism of neuroprotection by bioactive compounds. Techniques of Extraction, purification and concentration of bioactive compounds from fruits and vegetables. Bio active compound and health benefits Incorporation of bioactive compounds in foods.
- Block3: Neutraceuticals
- Unit I:Nutraceuticals Introduction, classification of nutraceuticals, dietary supplements, fortified foods, functional foods and phytonutraceuticals. Role of medicinal and aromatic plants in nutraceutical industry. Health benefits of phytoneutraceuticals.

#### **Suggested References**

- RosaLA, Alvarez-Parrilla Eand Gonzalez Aguilar GA.2009. *Fruit and Vegetable Phytochemicals: Chemistry, Nutritional Value and Stability,* Wiley-Blackwell, ISBN9780813803203.
- Senrawat R, Khan KA, Goyal MR and Paul PK. 2018.*Technological Interventions in the Processing of Fruits and Vegetables*, Apple Academic Press, ISBN 9781771885867.
- Vattem DA.2016. Functional Foods, Nutraceuticals and Natural Products: Concepts and Applications. DEStechPublications, Inc, ISBN9781605951010.
- Watson R Rand Preedy V.2009. *Bioactive Foods in Promoting Health: Fruits and Vegetables* (1st Edition), AcademicPress, ISBN9780123746283

# PHM 510Marketing and Entrepreneurship in Postharvest Horticulture(1+1)

#### 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).

## Practical

- Consumer Behaviour towards Processed Foods;
- An Empirical Test-Carrying out the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of successful Enterprises;
- Constraints in setting up of horti based industries;
- Field visits to study any one of the Local Financial Institutions to study the MSME Policies;
- Preparation of business plan and proposal writing-Project evaluation techniques;
- Discounted and undiscounted techniques;
- Case studies of successful entrepreneurs.

# **Suggested References**

- Adhikary MM. 2014.Enterprise and Entrepreneurship for Agri-Business Management and Planning.Daya Publishing House. New Delhi
- Bhaskaran S. 2014. Entrepreneurship Development and Management.Aman Publishing House, Meerut.
- Choudhury M and Barua N. 2014. Marketing of Processed Fruit and Vegetable. Daya Publishing House. New Delhi.
- Gaur SC. 2012.Handbook of Agro Food Processing and Marketing.Agrobios.Jodhpur Kadam MM and Bishe RN. 2018. Textbook on Agricultural Entrepreneurship. Narendra publishing house. New Delhi.
- Sudheer KP and Indira V. 2018.Entrepreneurship and Skill Development in Horticultural Processing.New India Publishing Agency. New Delhi.
- Sudheer KP and Indira V. 2018.Entrepreneurship Development in Food Processing.New India Publishing Agency. New Delhi

PHM 511Preservation by Fermentation and DehydrationI	1+1	
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## Theory

Block 1:Preservation by Fermentation

- Unit 1:Importance of preservation of horticultural produce by fermentation and dehydration.Principles and methods of preservation by fermentation Alcoholic, Acetic, Lactic. Factors affecting yeast and bacterial fermentation, Study of alcoholic fermentation with special reference to wine.
- Unit 2:History of wine making, present international and national status of wine production and wine market, scope and importance of wine industries, classification of wines, nutritional and therapeutic value of wine, technology of wine production. Different types of grape wines, production of wine from fruits other than the grapes. Commercial aspect of wine production.
- Unit 3:Preparation and preservation of other fermented products like vinegar, sauerkraut etc. Packaging technology, labeling and storage of wines and other fermented products.
- Block 2:Preservation by Dehydration
- Unit 1: Principles and techniques of dehydration, pretreatments and methods sun drying, shade drying and artificial drying, equipments - cabinet drier, tunnel drier, spray drier, fluidized bed drier, freeze drier, vacuum drier, solar drier, etc. Commodity requirements, drying rates, moisture levels, enzymes in dehydration processes.Packaging of dried products.

- Unit 2: Drying techniques for preparation of raisin, dried fig, banana fig, potato chips, peas, onion, mushroom, spices and plantation crops. Osmotic dehydration.Intermediate moisture foods (IMF}.
- Unit 3: Quality analysis of fermented and dehydrated products. Sanitation and cleaning requirements for winery and dehydration plants. Spoilages in fermented and dehydrated products.

## Practicals

- Study of equipments used in wine making.
- Preparation and preservation of grape wines dry wines, dessert wines, orange wine, otherfruit wines etc.
- Preparation and preservation of vinegar and sauerkraut.
- Lactic acid fermentation of non-acid vegetables cucumber, carrot, etc., as a prerequisite to pickling.
- Packaging of fermented products.
- Analysis of physico-chemical and sensory quality of wine and other fermented products.
- Study of equipments used in dehydration;
- Study of pretreatments for dehydration.
- Preparation of dried/dehydrated products raisin, banana, fig, potato, peas, onion, pepper, cardamom, mushroom, etc.
- Evaluation of different methods of drying sun drying, shade drying, artificial drying using electricity. Packaging of dried products.
- Analysis of quality of fermented and dehydrated products.
- Examination of spoilages in fermented and dehydrated products.
- Visit to processing factories winery, wine park and dehydration units.

# **Suggested Referencess**

- Arsdel WB, Copley MJ and Morgan AI. 1973. Food dehydration. 2nd Ed. Vol I and II.AVI Publication.
- Barbosa-Canovas GV. 2000. Dehydration of Foods. Chapman & Hall.
- Brian Mc Neil, Linda Harvey. PracticalsFermentation Technology.John Wiley & Sons, Inc.
- Hui YH, Clary C, Farid MM, Fasina OO, Noomhorm A and Welti-Chanes A. 2008.Food drying science and technology-microbiology, chemistry, applications. DE Stech Publications, Inc.
- Lal G, Siddappa GS and Tandon GL. 1998. Preservation of Fruits and Vegetables. ICAR.
- Loesecke. 2004. Drying and Dehydration of foods. AGROBIOS (India).
- Kirsten K. Shockey and Christopher Shockey 2014. Fermented Vegetables Storey Publishing.
- NIIR Board. The complete book on processing, dehydration, canning, preservation of fruits and vegetables. NIIR Board, New Delhi.
- Pak Lam Yu, P L Yu, Pak Lam Yu. Fermentation Technologies Industrial Applications.Springer.
- SandorElix Katz 2012.The art of Fermentation, Chelsea Green Publishing Co. Srivastava ML. Fermentation Technology.Narosa.
- Srivastava RP & Kumar S. 2003.Fruit and Vegetable Preservation-Principles and Practices.International Book Distributors.
- Stanbury PF, Hall S. and Whitaker A. 1998.Principles of Fermentation Technology.Elsevier Publication.
- Steinkraus KS. 1996. Handbook of Indigenous Fermented Foods. Marcel Dekker.

- Sudheer KP and Indira V. 2007.Post harvest technology for horticulture crops. New India publishing Agency.
- Verma LR and V.R. Josh LR. 2000. Post harvest technology of fruits and vegetables handling, processing, fermentation and waste management. Vol-2. Indus Publishing company.
- Yiu H. Hui and Y. H. Hui. 2004. Hand book of food and beverage fermentation technology. Marcel Dekker.

PHM 512	Preservation by Canning and Freezing	1+1
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- Block 1:Preservation by Canning
- Unit 1: Importance of preservation of horticultural produce by canning and freezing, present status and future scope. Principles and techniques for canning/bottling, containers for canning and bottling tin and glass containers, open top sanitary cans, technology and fabrication of tin plate, tin coating, lacquering, can seaming technology, equipments for canning and their operation.
- Unit 2: Unit operations in a canning line. Raw materials for canning/bottling, canning of important fruits/vegetables and their products.Aseptic canning methods, equipments.
- Unit 3: Processing determination of processing time and temperature, TDT and TDP, heat penetration studies and calculation of process time. Thermal process evaluation.
- Block 2:Preservation by Freezing
- Unit 1:Principles, equipments and techniques for freezing preservation of fruits, vegetables and their products slow freezing, quick freezing. Freezing methods air freezing, immersion freezing, indirect contact freezing, cryo freezing, dehydrofreezing.
- Unit 2: Package requirement for frozen products. Transportation of frozen products. Influence of freezing on the quality of frozen products.
- Unit 3:Microbial safety and quality analysis of canned and frozen products. Spoilages in canned and frozen products.

#### Practicals

- Study of equipments and machineries used in canning and bottling.
- Study of containers used in canning and bottling glass containers, open top sanitary cans.
- Operation of can reforming and seaming machines.
- Study of unit operations in canning line.
- Preparation of canned products pineapple, orange, mango, sapota, peas, cauliflower, etc.
- Determination of thermal death time curve.
- Heat penetration studies in canned product.
- Calculation of process time.
- Study of freezing machineries and frozen food storage equipments.
- Study of effect of slow and quick freezing.
- Preparation and preservation of frozen fruit and vegetable products.
- Packaging of frozen products.
- Sensory evaluation and quality analysis of canned, bottled and frozen products.
- Sanitation and cleaning requirements for processing plants.
- Study of spoilages in canned, bottled and frozen products. Corrosion of cans.
- Visit to canneries and freezing units.

#### **Suggested References**

- Cruess WV. 1997. Commercial fruit and vegetable products. Allied Scientific publisher.
- Lal G, Siddappa GS & Tandon GL. 1998. Preservation of Fruits and Vegetables. ICAR.
- NIIR Board. Hand book on fruits, vegetables Food processing with canning and preservation. Asia Pacific Business press Inc.
- Srivastava RP & Kumar S. 2003.Fruit and Vegetable Preservation-Principles and Practices.International Book Distributors.
- Tressler DK, Van Ardel WB and Copley MJ. 1969. The Freezing Preservation of foods. Vol I & II. AVI Publishing Co.
- Mallett CP. 1993. Frozen Food Technology.Blackie Academic & Professional.Yiu H. Hui. 2004. Hand book of frozen foods. Marcel Dekker.
- NIIR Board. 2003. The complete book on processing, dehydration, canning preservation of fruits & vegetables. NIIR project consultancy services.
- Jean Larousse and Bruce E. Brown. 1997. Food canning technology (Ed.). Wiley- VCH.
- Verma LR. & Joshi VK. 2000. Post Harvest Technology of Fruits and Vegetables. Vol. 2.Indus Publ.
- Sudheer KP and Indira V. 2007.Post harvest technology for horticulture crops. New India publishing Agency.

# PHM 513Processing Technology for Spices and Plantation Crops1+1

#### Theory

- Unit 1:Coconut Processing techniques for production of copra, coconut oil, desiccated coconut, coconut milk, cream, syrup, honey, toddy, etc. Packaging of tender coconut water.Byproducts of coconut cake, coconut fibre (coir}, coirpith, coconut shell, etc.Coir products and byproducts.Arecanut Processing techniques for production of Kottaipak (Chali}, kalipak, neetadaka, scented supari.Grading and storage.Utilization of byproducts.Oil Palm Processing techniques for extraction of oil from mesocarp and kernel. Refining of crude oil.Quality of oil.
- Unit 2:Cashewnut Processing cashew apple and preservation. Cashewnut processing, grading and packing.Byproducts - shell oil (CNSL}, testa tannin, etc.Cocoa Fermentation and drying of cocoa beans.Preparation of cocoa products - cocoa butter, powder, chocolate, etc.Chemistry of cocoa fermentation.Coffee Chemistry of constituents.Processing technology for production of cherry and parchment coffee.Changes taking place during fermentation, drying, roasting; Preparation of coffee powder and instant coffee.Grades of coffee.Chicory chemistry.Aderltarants used in coffee blending. Caffeine and its uses.Tea Harvesting time and methods.Techniques of tea manufacturing. Blending and grading. Types of tea.Standards of purity grades.Judging tea quality.Chemistry of tea.Rubber Collection and pre-processing of rubber latex. Processing of rubber latex into latex concentrates, sheet rubber, crepe rubber, block rubber, etc.
- Unit 3:Vanilla Curing of vanilla pods and extraction of oil.Betelvine Production of bleached leaves.Tamarind Processing technology for production of powder and paste.Kokum (Garciniaindica} Extraction and Preparation of fruit juice concentrate, carbonated and non-carbonated beverage.Pepper Processing technology for black pepper, white pepper, dehydrated green pepper, buff coloured pepper and canned green pepper, Extraction of oleoresin. Production of pepper oil.

- Unit 4:Cardamom Techniques of curing cardamom sun drying, flue curing. Production of green and white cardamom.Extraction of cardamom oil.Processing of large cardamom.Ginger Techniques of curing ginger - bleached and unbleached ginger, peeled whole ginger, sliced ginger, split ginger. Extraction of oleoresin and oil.Turmeric Techniques of curing turmeric.Extraction of oleoresin and curcumin.
- Unit 5:Tree spices Processing of nutmeg, clove and Cinnamon. Extraction of oil. Garlic Curing and extraction of oil. Curry leaf Extraction of oil and production of curry leaf powder. Chillies and paprika Extraction of oleoresin and pigments.
- Unit 6:Grading and packing of processed products of spices and plantation crops. Selection and types of packaging materials.Storage of processed products.Quality of processed products.

# Practicals

- Preparation of coconut products copra, desiccated coconut, coconut milk.
- Packaging of tender coconut water.
- Extraction of fibre from coconut husk.
- Preparation of Kalipak from tender arecanuts and scented supari.
- Processing of cashewnuts, grading and packaging of cashew kernels.
- Extraction, fermentation and drying of cocoa beans.
- Preparation of parchment coffee. Curing of vanilla pods.
- Bleaching of betelvine leaves.
- Preparation of tamarind paste and powder.
- Preparation of black and white pepper, dehydrated green pepper.
- Extraction of oleoresin and oil from pepper.
- Curing and drying of cardamom and extraction of oil.
- Curing of ginger and extraction of oleoresin.
- Curing of turmeric and extraction of oleoresin.
- Curing and extraction of oil from garlic.
- Extraction of curry leaf oil.
- Extraction of oleoresin from chillies.
- Detection of microbial quality and adulteration in spices, aromatic compounds in spices;
- storage and packaging of spices.
- Visit to spice and plantation crop processing Units.

## Suggested References

Banerjee B. 2002. Tea Production and Processing.Oxford Univ. Press.

Fellows PJ. 1988. Food Processing Technology. Ellis Horwood International. Switzerland.

Fennema OR. 1985. Food Chemistry. Marcel Dekker.

- Kumar N, Abdul Khader ML, Rangaswamy P & Ikrulappan I. 1994. Spices, Plantation Crops, Medicinal and Aromatic Plants.Rajalakshmi Publ.
- Dashora LK, AbhayDashora and Lakhawat SS. 2006. Production Technology of Plantation Crops, Spices, Aromatic and Medicinal Plants. Agrotech.

Mandal RC. 1996. Coconut Production and Processing Technology. Agro.Bot.

Mandal RC. 1997. Cashew Production and Processing Technology. Agro.Bot.

Chadha KL et al. (Eds.). 1993-95. Advances in Horticulture. Vol. IX. Plantation Crops and Spices.Malhotra Publishing House, New Delhi.
Minifie BW. 1999. Chocolate, Cocoa and Confectionery Technology. 3rd Ed. Aspen Publ.

- NAIR. 2004. Handbook on Spices. National Institute of Industrial Research Board, Asia Pacific Business Press Inc.
- Parthasarathy VA, Chempakam B and Zachariah TJ. 2008. Chemistry of spices. CABI
- Peter KV. (Ed.}. 2001. Handbook of Herbs and Spices. Vols.I-III. Wood Head Publishing Co., UK & CRC, USA.
- K.V. Peter., K.P. Sudheer, V. Indira., Post Harvest Technology of Horticultural Crops, Horticulture Science Series 7 Chief editor, new India publishing agency (NIPA)
- K.V. Peter., Plantation Crops by National Book Trust India, Page no. 84 and 85
- Pruthi JS. 2001(Reprint}.Major spices of India-Crop management and Postharvest Technology. ICAR, New Delhi.
- Pruthi JS. 1976. Spices and condiments. National Book Trust.
- Sudheer KP and Indira V. 2008.Post-Harvest Technology of Horticultural Crops.Horticulture Science Series.New India Publ. Agency.

Sivetz M and Foote HE. 1963. Coffee Processing Technology. AVI Publ.

# PHM 514 Postharvest Handling and Processing of Ornamental, Medicinal and 1+1 Aromatic Plants

#### Theory

- **Unit 1**:Importance and scope. Post harvest physiological and biochemical changes. Maturity indices; harvesting, grading, bunching of cut-flowers; Factors affecting cut-flower longevity; Pretreatments for extending the vase life of cut flowers, precooling, use of preservative solutions, growthregulators and other chemicals. Preparation of cut-flowers for market and transportation. Export requirement. Dutch auctioning system.
- Unit 2:Post harvest handling of aromatic and medicinal plants. Recommended storage techniques and condition for ornamentals, medicinal and aromatic plants.Processing of medicinal plants dioscorea, coleus, ashwagandha, tulsi, isabgol, safedmusli, etc.Different methods of drying and storage. Influence of temperature and time combination on active principles. Extraction and analysis of active principles. Distillation, solvent extraction from aromatic plants davana, mint, rosemary, rose, citronella, lavender, jasmine, etc. Identification of different odour factors in essential oil.

#### Practicals

- Maturity indices and harvesting;
- Equipments grading, sorting, cleaning and preparation for marketing.
- Studies on vase life of flowers.
- Maturity indices and harvesting of medicinal and aromatic plants.
- Study of processing of medicinal plants, their drying and storage.
- Extraction of essential oils from different aromatic plants.
- Distillation, solvent extraction from aromatic plants davana, mint, rosemary, rose, citronella, lavender, jasmine, etc.
- Physico-chemical and sensory evaluation of oils.
- Identification of different odour factors in essential oil with GLC.
- Extraction and analysis of active principles using TLC, HPLC, GC/CG-MS technology.

- Value added products from ornamentals, medicinal and aromatic plants.
- Visit to flower auction centre and essential oil extraction unit.

#### **Suggested References**

Atal CK and Kapur BM. 1982. Cultivation and utilization of medicinal plants. RRL., Jammu

Bhattacharjee SK and Dee LC. 2005. Post harvest technology of flowers and ornamental plants. Pointer Publishers, Jaipur.

Guenther E. The essential oils.Vol 1-6.

Kumar N, Abdul Khader ML, Rangaswamy P &Ikrulappan I. 1994. Spices, Plantation Crops, Medicinal and Aromatic Plants.Rajalakshmi Publ.

Masada Y.1986. Analysis of Essential Oil by Gas Chromatograph and Mass Spectrometry. John Wiley & Sons.

Panda H. 2002. Medicinal Plants Cultivation and their Uses. Asia Pacific Business Press.

- Peter KV. (Ed.}. 2001. Handbook of Herbs and Spices. Vols.I-III. Wood Head Publishing Co., UK & CRC, USA.
- Prajapati SS, Paero H, Sharma AK & Kumar T. 2006.A Hand book of Medicinal Plants.Agro Bios.
- WHO. 1998. Quality Control Methods for Medicinal Plants Materials. WHO.

# PHM 515In-plant Training and Management of Waste from Horticultural1+1Processing Industries

## Theory

- Unit 1:Waste & its consequences in pollution and global warming, Need for waste management. Waste characteristics - sampling methods, analysis and standards for waste discharge.Survey and nature of waste from processing industry and their present disposal methods.
- Unit 2:Methods for waste and waste water reduction. In plant modifications and innovative processes. Recovery of useful materials from waste, viz., colour, essence, pectin, oils, etc. Utilisation of waste and by-products new products, animal feed and single cell protein.
- Unit 3:Technology of treatments of waste effluent from fruit and vegetable industries. Immobilised bioreactor in waste treatment.Anaerobic bioreactor and energy production.Economics of effluent management.

### Practicals

The student will be attached to a unit associated with commercial fresh produce handling, storage and marketing, where the student receives Practicalstraining in various aspects of post harvest handling viz., harvesting, sorting and grading, pre-storage treatments, packing, storage, transport and marketing. Or the student will be attached to a processing unit where the student will attend to various unit operations involved in processing of different fruits, vegetables, spices or plantation crops. The student will maintain daily production schedule of finished products and utilization of raw material. The student has to understand and critically study the waste management practice in both fresh and processed product industries. The student is required to submit a detailed report of their training along with the layout plan of unit they attended.

#### **Suggested Referencess**

Verma LR and Josh VR. 2000. Post harvest technology of fruits and vegetableshandling, processing, fermentation and waste management. Vol-2.Indus Publishing company.

Ioannis S. Arvanitoyannis. 2007. Waste Management for the Food Industries.

PHM 516 Process Engineering in Horticultural Crops	1+1
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## Theory

- Unit 1:Importance and scope, conveying and elevating equipment, physical and thermal properties of horticultural commodities; Rheological and texturalproperties; Heating processes; Thermal process calculation; Heating equipment applied to processing viz., jacketed pan, bath, plate and tubular heat exchanger; Evaporator in food industries, multiple effect and multistage evaporator, size reduction;
- Unit 2:Features and design specifications; Planning for domestic as well as commercial storage facilities; Drying equipment; Classification of filtration equipment and outline; Equipment in cannery; kinetics of growth and enzyme reactions; Fermentation; Equipment and product recovery; Discharge of industrial waste; Freezing equipment; Unit operations of processing.

## Practicals

- Handling of harvesting equipments;
- Determination of physical and thermal properties; 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.

## **Suggested Referencess**

Heldman DR and Singh RP.1984.Food Process Engineering. AVI Publ.

Romeo T. Toledo. Fundamentals of food process engineering, 2nd edition. CBS Publishers and Distributors.

Sahay KM & Singh KK. 1994. Unit Operation of Agricultural Processing.Vikas Publ. House. Singh RP & Heldman DR. 1993.Introduction to Food Engineering. Academic

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## Theory

Unit 1:Horticulture food chain, Hazards - biological, chemical, physical; Quality assurance system and food safety; Challenges and opportunities for developing country exports; Reasons for implementing food safety and quality standards; Sampling procedures and plans;

- Unit 2:Food Safety and Standards Act, 2006; Strategies for compliance with international agrifood standards; Design and implementation of an HACCP system; Steps in the risk management process; Traceability in food supply chains; microbial and chemical analysis of food;
- Unit 3:Various organizations dealing with inspection, traceability and authentication, certification and quality assurance such as FSSA, APEDA, etc. Indian and International quality systems and standards like Codex Alimentarius, ISO, etc. Consumer perception of safety; Ethics in food safety.

### **Suggested References**

Export/Import policy by Govt. of India.

Graham HD. 1980. Safety of Foods. AVI Publ. Co.

- Krammer A & Twigg BA.1973. Quality Control in Food Industry. Vol.I, II. AVI Publ.
- Luning PA, Devlieghere F and Verhe R. 2007.Safety in the agri-food chain.Wageningen Academic Publishers.
- Macrae R, Roloson R &Sadlu MJ. 1994. Encyclopedia of Food Science & Technology & Nutrition. Vol. XVI. Academic Press.

Peter KV. 2008. Basics in Horticulture. New India Publ. Agency.

Ranganna S. 2001. Handbook of Analysis and Quality Control for Fruit and Vegetable Products.2nd Ed. Tata-McGraw-Hill.

Mahindru SN. 2004. Food Safety Concepts and Reality. APH Publ. Corp. Press.

ENTOMOLOGY	
Course	

Sl.No.	Code	Course	Credit Hours
Major	courses (20 ci	redits)	
1	ENT 501*	Insect Morphology	2+1
2	ENT 502*	Insect Anatomy and Physiology	2+1
3	ENT 503*	Insect Taxonomy	1+2
4	ENT 504	Insect Ecology	2+1
5	ENT 505*	Biological Control of Crop Pests and Weeds	2+1
6	ENT 506	Toxicology of Insecticides	2+1
7	ENT 507	Host Plant Resistance	1+1
8	ENT 508	Concepts of Integrated Pest Management	2+0
9	ENT 509	Forest Entomology	1+1
10	ENT 510*	Pests of Horticultural and Plantation Crops	2+1
11	ENT 511	Post Harvest Entomology	1+1
12	ENT 512	Insect Vectors of Plant Pathogens	1+1
13	ENT 513	Principles of Acarology	1+1
14	ENT 514	Vertebrate Pest Management	1+1
15	ENT 515	Techniques in Plant Protection	0+1
16	ENT 516	Apiculture	2+1
17	ENT 517	Medical and Veterinary Entomology	1+1
18	ENT 518	Lac Culture	1+1
19	ENT 519	Molecular Approaches in Entomology	2+1
20	ENT 520	Plant Quarantine, Bio-safety and Bio-security	2+0
21	ENT 521	Edible and Therapeutic Insects	1+1
22	ENT 571	Qualifying Examination	0+2
23	ENT 581	Seminar-I	0+1
24	ENT 582	Seminar-II	0+1
25	ENT 591	Research	0+27

\* Compulsory among major courses

- Unit I : External Morphology: Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation. Head- Origin, structure and modification; mouthparts, antennae, their types and functioning; tentorium and neck sclerites. Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; legs: structure and modifications. Abdomen- Segmentation and appendages; genitalia and their modifications; embryonic and post-embryonic development.
- Unit II : Insect sense organs (mechano-, photo- and chemo- receptors); organogenensis at pupal stage; insect defense; chaetotaxy; morphological traits in relation to forensic entomology.
- Unit III : Types of immature stages in insect orders, morphology of egg, nymph/ larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in hemi-metabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

## **Practical:**

- Preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia
- Dissection of genitalia. Types of immature stages in insects; their collection, rearing and preservation
- Identification of immature insects to orders and families, in endopterygote orders, viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using key

## **Suggested References**

- Chapman RF. 1998. The Insects: Structure and Function. Cambridge Univ. Press, Cambridge.
- Chu HF. 1992. How to Know Immature Insects. William Brown Publication, Iowa.
- Duntson PA. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publishers, New Delhi.
- Evans JW. 2004. Outlines of Agricultural Entomology. Asiatic Publ., New Delhi.
- Gillott C. 1995. Entomology, 2nd Ed. Plenum Press, New York, London.
- Gullan PJ and Cranston PS. 2000. The Insects, An Outline of Entomology, 2nd Ed. Blackwell Science, UK.
- Peterson A. 1962. Larvae of Insects. Ohio University Press, Ohio.
- Richards OW and Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman and Hall, London.
- Snodgross RE. 1993. Principles of Insect Morphology. Cornell Univ. Press, Ithaca.
- Tembhore DB. 2000. Modern Entomology, Himalaya Publishing House, Mumbai.

Stehr FW. 1998. Immature Insects. Vols. I, II. Kendall Hunt Publication, Iowa.

- Unit I: Scope and importance of insect physiology; physiology of integument, moulting,chemistry of cuticle, biosysthesis of chitin; growth, hormonal control, metamorphosisand diapause; pheromone secretion, transmission, perception and reception
- Unit II : Physiology and mechanism of digestion, circulation, respiration, excretion, reproduction, secretion (exocrine and endocrine glands) and nerve impulse transmission in insects.
- Unit III : Importance of insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.

## **Practical:**

- Latest analytical techniques for analysis of free amino acids of haemolymph
- Determination of chitin in insect cuticle
- Examination and count of insect haemocytes; preparation and evaluation of various
- diets
- Consumption, utilization and digestion of natural and artificial diets.

## **Suggested References**

Chapman RF. 1998. Insects: Structure and Function. ELBS Ed., London.

- Duntson PA. 2004. The Insects: Structure, Function and Biodiversity. Kalyani Publishers, New Delhi.
- Gullan PJ and Cranston PS. 2000. The Insects: An Outline of Entomology, 2nd Ed. Blackwell Science, UK.
- Kerkut GA and Gilbert LI. 1985. Comprehensive Insect Physiology, Biochemistry and
- Pharmacology. Vols. I-XIII. Pergamon Press, New York.
- Patnaik BD. 2002. Physiology of Insects. Dominant Publishers, New Delhi.
- Richards OW and Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Vol. 1. Structure, Physiology and Development. Chapman and Hall, New York.
- Simpson SJ. 2007. Advances in Insect Physiology, Vol. 33, Academic Press (Elsevier), London, UK.

Wigglesworth VB. 1984. Insect Physiology. 8th Ed. Chapman and Hall, New York.

- Unit I: History of insect classification; principles of systematics and its importance. Identification, purpose, methods character matrix, taxonomic keys. Descriptionssubjects of descriptions, characters, nature of characters, analogy v/s homology, parallel v/s convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism. Brief evolutionary history of insects introduction to phylogeny of insects and Classification of Superclass Hexapoda Classes Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses. Process of speciation and interbreeding allopatric species. Molecular systemnatics, DNA barcoding, karyological and biochemical approaches in taxonomy. Insect labeling protocols and procedures.
- Unit II : Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.
- Unit III : Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

## Practical

- Study of Orders of insects and their identification using taxonomic keys
- Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera;
- Field visits to collect insects of different orders.

## **Suggested References**

- CSIRO 1990. The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.
- Freeman S and Herron JC. 1998. Evolutionary Analysis. Prentice Hall, New Delhi.
- Gullan PJ and Cranston PS. 2010. The Insects: An outline of Entomology. 4th Ed. Wiley-Blackwell Publications, West Sussex, UK.
- Mayr E. 1971. Principles of Systematic Zoology. Tata McGraw Hill, New Delhi.
- Richards OW and Davies RG. 1977. Imm's General Text Book of Entomology. 10th Ed. Chapman and Hall, London.
- Ross HH.1974. Biological Systematics. Addison Wesley Publ. Company.

Triplehorn CA and Johnson NF. 1998. Borror and DeLong's Introduction to the Study of Insects. 7th Ed. Thomson/ Brooks/ Cole, USA/ Australia.

# ENT 504 Insect Ecology 2+1

#### Theory

- Unit I: History and definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance vs Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects-Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology.
- Unit II : Basic concepts of abundance- Model vs Real world. Population growth basic models Exponential vs Logistic models. Discrete vs Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital StatisticsLife Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundanceEnvironmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) – aestivation, hibernation
- Unit III : Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of niche ecological homologues, competitive exclusion. Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.
- Unit IV: Community ecology- Concept of guild, Organisation of communities- Hutchinson Ratio, May's d/w, Relation between the two and their association with Dyar's Law and Przibram's law. Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity- stability debate, relevance to pest management. Pest management as applied ecology. Climate change and insect pest/ natural enemy population; ecological engineering.

#### Practical

- Types of distributions of organisms
- Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution
- Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit
- Fitting Holling's Disc equation
- Assessment of prey-predator densities from natural systems and understanding the correlation between the two
- Assessing and describing niche of some insects of a single guild
- Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms

- Calculation of diversity indices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values
- Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

#### **Suggested References**

- Begon M, Townsend CR and Harper JL. 2006. Ecology: From Individuals to Ecosystems. 4th Ed. Blackwell Publishing, USA/ UK/ Australia.
- Chapman JL and Reiss MJ. 2006. Ecology: Principles and Applications. 2nd Ed. Cambridge Univ. Press, Cambridge.
- Fowler J, Cohen L and Jarvis P. 1998. PracticalsStatistics for Field Biology. 2nd Ed. John Wiley & Sons, Chichester, West Sussex PO19 8SQ, England.
- Gotelli NJ and Ellison AM. 2004. A Primer of Ecological Statistics. Sinauer Associates, Inc., Sunderland, MA.
- Gotelli NJ. 2001. A Primer of Ecology. 3rd Ed. Sinauer Associates, Inc., Sunderland, MA
- Gupta RK. 2004. Advances in Insect Biodiversity. Agrobios, Jodhpur.
- Krebs CJ. 1998. Ecological Methodology. 2nd Ed. Benjamin-Cummings Publ. Co., New York.
- Krebs CJ. 2001. Ecology: The Experimental Analysis of Distribution and Abundance. 5th Ed. Benjamin-Cummings Publ. Co., New York.
- Magurran AE. 1988. Ecological Diversity and its Measurement. Princeton Univ. Press, Princeton.
- Price PW. 1997. Insect Ecology. 3rd Ed. John Wiley, New York.
- Real LA and Brown JH. (Eds). 1991. Foundations of Ecology: Classic Papers with Commentaries. University of Chicago Press, Chicago.
- Schowalter Timothy D. 2011. Insect Ecology An Ecosystem Approach. 3rd Ed. Academic Press, London, UK/ CA, USA.
- Southwood TRE and Henderson PA. 2000. Ecological Methods. 3rd Ed. Methuen and Co. Ltd., London.
- Speight MR, Hunta MD and Watt AD. 2006. Ecology of Insects: Concepts and Application. Elsevier Science Publ., The Netherlands.
- Townsend Colin R, Begon Michael and Harper John L. 2008. Essentials of Ecology. 3rd Ed. Blackwell Publishing, USA/ UK/ Australia.
- Wilson EO, William H and Bossert WH. 1971. A Primer of Population Biology. Harvard University, USA.
- Wratten SD and Fry GLA. 1980. Field and Laboratory Exercises in Ecology. Arnold, London.

ENT 505	<b>Biological Control of Crop Pests and Weeds</b>	2+1
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- Unit I : History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.
- Unit II : Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa, etc., their mode of action. Biological control of weeds using insects. Epizootiology,

symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

- Unit III : Mass production of quality bio-control agents- techniques, formulations, economics, field release/ application and evaluation. Development of insectaries, their maintenance.
- Unit IV: Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

## Practical

- Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers
- Visits to bio-control laboratories to learn rearing and mass production of egg, egglarval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds
- Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

## **Suggested References**

Burges HD and Hussey NW. (Eds). 1971. Microbial Control of Insects and Mites. Academic Press, London.

De Bach P. 1964. Biological Control of Insect Pests and Weeds.

Chapman and Hall, New York. Dhaliwal GS and Arora R. 2001. Integrated Pest Management: Concepts and Approaches. Kalyani Publishers, New Delhi.

Gerson H and Smiley RL. 1990. Acarine Biocontrol Agents – An Illustrated Key and Manual.

- Chapman and Hall, New York. Huffaker CB and Messenger PS. 1976. Theory and Practices of Biological Control. Academic Press, London.
- Ignacimuthu SS and Jayaraj S. 2003. Biological Control of Insect Pests. Phoenix Publ., New Delhi.

Saxena AB. 2003. Biological Control of Insect Pests. Anmol Publ., New Delhi.

Van Driesche and Bellows TS. Jr. 1996. Biological Control. Chapman and Hall, New York.

ENT 506	Toxicology of Insecticides	2+1	
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- Unit I : Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.
- Unit II : Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature; categorization of insecticides on the basis of toxicity – criteria for bees, beneficial insects and other insects in general; structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds/ new insecticide molecules; nanopesticides; drawbacks of insecticide abuse.
- Unit III : Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticidessynergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity. bioassay definition, objectives, criteria, factors, problems and solutions.

- Unit IV: Insecticide metabolism; insect-pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.
- Unit V: Insecticide residues, their significance and environmental implications; procedures of insecticide residue analysis. Insecticide Act, registration procedures, label claim, and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

#### **Practical:**

- Insecticide formulations and mixtures
- Working out doses and concentrations of pesticides
- Evaluation of insecticide toxicity: Bioassay techniques AND Probit analysis
- Laboratory and field evaluation of bio-efficacy of insecticides
- Toxicity to beneficial insects
- Pesticide appliances
- Procedures of residue analysis.

## **Suggested References**

- Chattopadhyay SB. 1985. Principles and Procedures of Plant Protection. Oxford and IBH, New Delhi.
- Dodia DA, Petel IS and Petal GM. 2008. Botanical Pesticides for Pest Management. Scientific Publisher (India), Jodhpur.
- Dovener RA, Mueninghoff JC and Volgar GC. 2002. Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA
- Gupta HCL.1999. Insecticides: Toxicology and Uses. Agrotech Publ., Udaipur.
- Ishaaya I and Degheele (Eds.). 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.
- Ishaaya I and Degheele D. 1998. Insecticides with Novel Modes of Action: Mechanism and Application. Norosa Publishing House, New Delhi
- Krieger RI. 2001. Handbook of Pesticide Toxicology. Vol-II. Academic Press. Orlando Florida
- Mathews GA. 2002. Pesticide Application Methods. 4th Ed. Intercept. UK.
- Matsumura F. 1985. Toxicology of Insecticides. Plenum Press, New York.
- Otto D and Weber B. 1991. Insecticides: Mechanism of Action and Resistance. Intercept Ltd., UK.
- Pedigo LP and Marlin ER. 2009. Entomology and Pest Management, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.
- Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi.

Prakash A and Rao J. 1997. Botanical Pesticides in Agriculture. Lewis Publication, New York. Roy NK. 2006. Chemistry of Pesticides. Asia Printograph Shahdara Delhi.

# ENT 507Host Plant Resistance1+1

- Unit I : History and importance of resistance; principles, classification, components, types and mechanisms of resistance.
- Unit II: Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

- Unit III : Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance acquired and induced systemic resistance.
- Unit IV: Factors affecting plant resistance including biotypes and measures to combat them
- Unit V: Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.
- Unit VI: Role of biotechnology in plant resistance to insects.

#### Practical

- Screening techniques for measuring resistance;
- Measurement of plant characters and working out their correlations with plant resistance;
- Testing of resistance in important crops
- Bioassay of plant extracts of susceptible/ resistant varieties
- Demonstration of antibiosis, tolerance and antixenosis.

#### **Suggested References**

- Dhaliwal GS and Singh R. (Eds). 2004. Host Plant Resistance to Insects -Concepts and Applications. Panima Publ., New Delhi.
- Maxwell FG and Jennings PR. (Eds). 1980. Breeding Plants Resistant to Insects. John Wiley and Sons, New York.

Painter RH. 1951. Insect Resistance in Crop Plants. MacMillan, London.

Panda N and Khush GS. 1995. Plant Resistance to Insects. CABI, London.

Smith CM. 2005. Plant Resistance to Arthropods – Molecular and Conventional Approaches. Springer, Berlin.

ENT 508	Concepts of Integrated Pest Management	2+0
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- Unit I : History, origin, definition and evolution of various terminologies. Importance of resistance, principles, classification, components, types and mechanisms of resistance. National and international level crop protection organizations; insecticide regulatory bodies; synthetic insecticide, bio-pesticide and pheromone registration procedures; label claim of pesticides – the pros and cons.
- Unit II : Concept and philosophy, ecological principles, economic threshold concept and economic consideration. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.
- Unit III : Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; semiochemicals, biotechnological and biorational approaches in IPM. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; costbenefit ratios and partial budgeting; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organic farming; components of ecological engineering with successful examples.

Unit IV: Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses; global and Indian scenario of crop losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system. Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

#### **Suggested References**

- Dhaliwal GS and Arora R. 2003. Integrated Pest Management Concepts and Approaches. Kalyani Publishers, New Delhi.
- Horowitz AR and Ishaaya I. 2004. Insect Pest Management: Field and Protected Crops. Springer, New Delhi.
- Ignacimuthu SS and Jayaraj S. 2007. Biotechnology and Insect Pest Management. Elite Publ., New Delhi.
- Norris RF, Caswell-Chen EP and Kogan M. 2002. Concepts in Integrated Pest Management. Prentice Hall, New Delhi.

Pedigo RL. 2002. Entomology and Pest Management. 4th Ed. Prentice Hall, New Delhi.

Subramanyam B and Hagstrum DW. 1995. Integrated Management of Insects in Stored Products. Marcel Dekker, New York.

8,	ENT 509 I	Forest Entomology	1+1
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- Unit I : Introduction to forestry in the tropics, tropical forests: characteristics and types of tropical forests, management of tropical forests and the problems in their management; plantation forestry: beginnings, expansion and current status.
- Unit II : History of tropical forest entomology, diversity of forest insects: structural and functional diversity the feeding guilds, concept of pests, ecology of insects in forest environment, concept and functioning of ecosystem, role of insects in ecosystem processes of tropical forests: insects as primary consumers, secondary and tertiary consumers, as decomposers, as food, pollinators and other ecological interactions.
- Unit III : Insect pests in natural forests, general pest incidence, pest outbreaks: Lepidoptera, Coleoptera, Hemiptera, and Hymenoptera; insect pests in plantations, nursery pests, sapling pests, pests of older plantations and their impact; insect pests of stored timber, categories of wood destroying insects and their damage: termites and beetles.
- Unit IV : Population dynamics, characteristics of population growth, factors affection population growth, principles governing population dynamics, types and causes of forest insect outbreaks; general issues in forest entomology: enemies' hypothesis, resource concentration hypothesis, pest evolution hypothesis; pest problems in plantations of indigenous *vs* exotic species; pest problems in monocultures *vs* mixed plantations.
- Unit V : Management of tropical forest insect pests, historical development and present status of tropical forest pest management, overview of pest management options: preventive measures, remedial measures; unique features of forest pest management; constraints to forest pest management in the tropics; guidelines for the practice of forest pest management in the tropics.
- Unit VI : Insect pests in plantations: Location-specific case studies.

## Practicals

Collection, identification and preservation of important insect pest specimens of forest plants and some damage material;

- Detection of insect infestation and assessment of losses due to insect pests;
- Habitat management for vertebrate and insects pests;
- Fire control methods and devices;
- Familiarization with the meteorological and plant protection equipment, application of pesticides and bio-control agents in the management of insect pests in nurseries and plantations.

## **Suggested References**

Jha LK and Sen Sarna PK. 1994. Forest Entomology. Ashish Publishing House, Delhi.
Nair KSS. 2007. Tropical Forest Insect Pests: Ecology, Impact, and Management, Cambridge University Press, Edinburgh/ New York.
Stebbings EP. 1977. Indian Forest Insects. JK Jain Brothers.

# ENT 510Pests of Horticultural and Plantation Crops2+1

## Theory

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops.

- Unit I : Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, ber, fig, citrus, aonla, pineapple, apple, peach and other temperate fruits.
- Unit II : Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, French beans, chow-chow, brinjal, okra, all gourds, drumstick, leafy vegetables, etc.
- Unit III : Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa, etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine, etc.
- Unit IV: Ornamental, medicinal and aromatic plants and pests in polyhouses/ protected cultivation.

# Practicals

- Collection and identification of important pests and their natural enemies on different crops
- Study of life history of important insect pests and non-insect pests

## Suggested References

- Atwal AS and Dhaliwal GS. 2002. Agricultural Pests of South Asia and their Management. Kalyani Publishers, New Delhi.
- Butani DK and Jotwani MG. 1984. Insects and Vegetables. Periodical Expert Book Agency, New Delhi.
- Dhaliwal GS, Singh R and Chhillar BS. 2006. Essential of Agricultural Entomology. Kalyani Publishers, New Delhi.
- Srivastava RP. 1997. Mango Insect Pest Management. International Book Distr., Dehra Dun.
- Verma LR, Verma AK and Goutham DC. 2004. Pest Management in Horticulture Crops: Principles and Practices. Asiatech Publ., New Delhi.

- Unit I : Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses in toto vis-à-vis total production of food grains in India. Scientific and socio-economic factors responsible for grain losses. Concept of seed vault.
- Unit II : Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.
- Unit III : Ecology of insect pests of stored commodities/ grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.
- Unit IV: Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/ sanitation, disinfestations of stores/ receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical controlprophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Insecticide resistance in stored product pests and its management; recent advances (MAS, PPP, HS) in storage pest management; integrated approaches to stored grain pest management.

## **Practical:**

- Collection, identification and familiarization with the stored grains/ seed insect pests and nature of damage caused by them
- Detection of hidden insect infestation in stored food grains
- Estimation of uric acid content in infested produce; estimation of losses in stored food grains
- Determination of moisture content in stored food grains
- Familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques
- Treatment of packing materials and their effect on seed quality
- Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, Mysore; IGSMRI, Hapur, etc. (only where logistically feasible).

#### **Suggested References**

Hall DW. 1970. Handling and Storage of Food Grains in Tropical and Subtropical Areas. FAO. Agricultural Development Paper No. 90 and FAO, Plant Production and Protection Series No. 19, FAO, Rome. Jayas DV, White NDG and Muir WE. 1995. Stored Grain Ecosystem. Marcel Dekker, New York.
Khader V. 2004. Textbook on Food Storage and Preservation. Kalyani Publishers, New Delhi.
Khare BP. 1994. Stored Grain Pests and Their Management. Kalyani Publishers, New Delhi.
Subramanyam B and Hagstrum DW. 1995. Interrelated Management of Insects in Stored Products. Marcel Dekker, New York.

#### Theory

- Unit I: History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.
- Unit II : Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.
- Unit III : Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.
- Unit IV: Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.
- Unit V: Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

#### **Practical:**

- Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes;
- Culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies;
- Vector rearing and maintenance;
- Estimating vector transmission efficiency, studying vector-virus host interaction.

#### **Suggested References**

Basu AN. 1995. *Bemisia tabaci* (Gennadius) – *Crop Pest and Principal Whitefly Vector of Plant Viruses*. Oxford and IBH, New Delhi.

- Harris KF and Maramarosh K. (Eds.). 1980. Vectors of Plant Pathogens. Academic Press, London.
- Maramorosch K and Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.
- Youdeovei A and Service MW. 1983. *Pest and Vector Management in the Tropics*. English Language Books Series, Longman, London.

ENT 513Principles of Acarology1+1	
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- Unit I: History of Acarology; importance of mites as a group; habitat, collection and preservation of mites. Soil arthropods and their classification, habitats and their identification.
- Unit II : Introduction to morphology and biology of mites and ticks. Broad classification major orders and important families of Acari including diagnostic characteristics. Estimation of populations; sampling and extraction methods for soil arthropods.

Unit III : Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens, etc. Culturing of phytophagous, parasitic and predatory mites. Mode of action of acaricides, resistance of mites and ticks to acaricides, its management.

## **Practical:**

- Collection of mites from plants, soil and animals;
- Extraction of mites from soil, plants and stored products;
- Preparation of mounting media and slide mounts;
- External morphology of mites;
- Identification of mites up to family level using keys;
- Studying different rearing techniques for mites.

#### Suggested References

- Anderson JM and Ingram JSI. 1993. Tropical Soil Biology and Fertility: A Handbook of Methods. CABI, London.
- Chhillar BS, Gulati R and Bhatnagar P. 2007. Agricultural Acarology. Daya Publ. House, New Delhi.
- Dindal DL. 1990. Soil Biology Guide. A Wiley-InterScience Publ., John Wiley and Sons, New York.
- Gerson U and Smiley RL. 1990. Acarine Biocontrol Agents An Illustrated Key and Manual. Chapman and Hall, NewYork.
- Gupta SK. 1985. Handbook of Plant Mites of India. Zoological Survey of India, Calcutta.
- Gwilyn O and Evans GO. 1998. Principles of Acarology. CABI, London.
- Jeppson LR, Keifer HH and Baker EW. 1975. *Mites Injurious to Economic Plants*. University of California Press, Berkeley.
- Krantz GW. 1970. A Manual of Acarology. Oregon State Univ. Book Stores, Corvallis, Oregon.
- Pankhurst C, Dube B and Gupta, V. 1997. Biological Indicators of Soil Health. CSIRO, Australia.
- Qiang Zhiang Z. 2003. Mites of Green Houses- Identification, Biology and Control. CABI, London.
- Sadana GL. 1997. False Spider Mites Infesting Crops in India. Kalyani Publishers House, New Delhi.
- Walter DE and Proctor HC. 1999. Mites- Ecology, Evolution and Behaviour. CABI, London.
- Veeresh GK and Rajagopal D. 1988. *Applied Soil Biology and Ecology*. Oxford and IBH Publ., New Delhi.

ENT 514	Vertebrate Pest Management	1+1

- Unit I : Introduction to vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals.
- Unit II : Bio-ecology of birds of agricultural importance, patterns of pest damage and assessment, roosting and nesting systems in birds; management of pestiferous birds; conservation of predatory birds.
- Unit III : Bio-ecology of rodents of agricultural importance, patterns of pest damage and assessment, burrowing pattern and habitat of rodents; management of pestiferous rodents.

- Unit IV: Bio-ecology of higher vertebrates of agricultural importance, patterns of damage and assessment, their habitat; management of pestiferous vertebrates.
- Unit V: Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods Operational practices- baiting, equipments and educative programmes.

## Practical

- Identification of important rodents, birds and other vertebrate pests of agriculture, food preference and hoarding;
- Social behaviour, damage assessment, field survey, population estimation, management strategies: preventive and curative methods.

## **Suggested References**

Ali S. 1965. *The Book of Indian Birds*. The Bombay Natural History Society, Bombay. Fitzwater WD and Prakash I. 1989. *Handbook of Vertebrate Pest Control*. ICAR, New Delhi.

Prakash I and Ghosh PK. 1997. *Rodents in Indian Agriculture*. Vol. I. State of Art Scientific Publ., Jodhpur.

Prakash I and Ghosh RP. 1987. Management of Rodent Pests. ICAR, New Delhi.

Prater SH. 1971. *The Book of Indian Animals*. The Bombay Natural History Society, Bombay. Rahman A. 2020. *Protective and Productive Entomology* Narendra Publishing House, New Delhi

ENT 515 Techniques in Plant Protection	0+1	
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#### Practical

- Pest control equipments, principles, operation, maintenance, selection, and application of pesticides;
- Release of bio-control agents;
- Seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticide application through irrigation water;
- Application of drones in plant protection;
- Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers;
- Uses of light, transmission and scanning electron microscopy;
- Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/ PAGE;
- Use of tissue culture techniques in plant protection;
- Computer application for predicting/ forecasting pest attack and identification.

#### **Suggested References**

Alford DV. 1999. *A Textbook of Agricultural Entomology*. Blackwell Science, London. Crampton JM and Eggleston P. 1992. *Insect Molecular Science*. Academic Press, London.

- Unit I : Historical development of apiculture at global level and in India; Classification of bees; global distribution of genus *Apis* and races; Morphology and anatomy of honey bee; Honey bee biology, ecology, adaptations; Honey bee behaviour nest founding, comb construction, brood care, defense, other in-house and foraging activities; Bee pheromones; Honey bee communication.
- Unit II : Commercial beekeeping as an enterprise; Design and use of bee hives; Apicultural equipment; Seasonal bee husbandry; Honey bee nutrition and artificial diets; Absconding, swarming, drifting causes and management; Curbing drone rearing; Laying worker menace causes, signs and management.
- Unit III : Bee genetics; Principles and procedures of bee breeding; Screening of honey bee colonies; Techniques in mass queen bee rearing; Mating nuclei and their establishment; Selective mating; Queen bee management; Bee packages.
- Unit IV : Ectoparasitic and endoparasitic bee mites biology, ecology, nature and symptoms of damage, management tactics; Wax moths, wasps and ants biology, ecology, nature and symptoms of damage, management tactics; Predatory birds, their damage potential and management tactics; Various diseases of honey bees and their management, Pesticide poisoning to honey bees, signs and protection; Protocols in evaluation of pesticide toxicity to honey bees.
- Unit V : Honey composition, properties, crystallization, post-harvest handling and processing; Honey quality standards and assessment; Apicultural diversification – potential and profitability; Production/ collection of bee pollen, propolis, royal jelly, bee venom and bees wax and their post-harvest handling; Apitherapy; Value addition of hive products; Development of apiculture project.
- Unit VI : Non-*Apis* pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops.

## Practical

- Morphological characteristics of honey bee;
- Mouthparts; digestive, respiratory, nervous system and reproductive Excretary systems adaptations in different castes of honey bees;
- Recording of colony performance;
- Seasonal bee husbandry practices;
- Swarming, queenlessness, swarming, laying workers menaces, etc. and their remedies;
- Innovative techniques in mass queen bee rearing; selection and breeding of honey bees;
- Instrumental insemination; formulation of artificial diets and their feeding;
- Production technologies for various hive products;
- Bee enemies and diseases and their management;
- Recording pollination efficiency;
- Application of various models for determining pollination requirement of crop;
- Developing a beekeeping project.

#### **Suggested References**

- Abrol DP and Sharma D. 2009. *Honey Bee Mites and Their Management*. Kalyani Publishers, New Delhi, India.
- Abrol DP. 2009. Honey bee Diseases and Their Management. Kalyani Publishers, New Delhi, India.
- Abrol DP. 2010. *Beekeeping: A Compressive Guide to Bees and Beekeeping*. Scientific Publishers, India.
- Abrol DP. 2010. Bees and Beekeeping in India. Kalyani Publishers, New Delhi, India.
- Abrol DP. 2012. Pollination Biology: Biodiversity Conservation and Agricultural Production.Springer.
- Atwal AS. 2001. World of Honey Bees. Kalyani Publishers, New Delhi- Ludhiana, India.
- Atwal AS. 2000. *Essentials of Beekeeping and Pollination*. Kalyani Publishers, New Delhi-Ludhiana, India.
- Bailey L and Ball BV. 1991. Honey Bee Pathology. Academic Press, London.
- Crane Eva and Walker Penelope. 1983. The Impact of Pest Management on Bees and Pollination.
- Tropical Development and Research and Institute, London.
- Free JB. 1987. Pheromones of Social Bees. Chapman and Hall, London.
- Gatoria GS, Gupta JK, Thakur RK and Singh Jaspal. 2011. Mass Multiplication of Honey Bee Colonies. ICAR, New Delhi, India.
- Grahm Joe M. 1992. Hive and the Honey Bee. Dadant & Sons, Hamilton, Illinois, USA.
- Grout RA. 1975. Hive and the Honey Bee. Dadant & Sons, Hamilton, Illinois, USA.
- Holm E. 1995. Queen Rearing Genetics and Breeding of Honey Bees. Gedved, Denmark.
- Laidlaw HH Jr and Eckert JE. 1962. Queen Rearing. Berkeley, University of California Press.
- Laidlaw HH. 1979. Contemporary Queen Rearing. Dadant & Sons, Hamilton, Illinois, USA.
- Mishra RC. 2002. Perspectives in Indian Apiculture. Agro-Botanica, Jodhpur, India.
- Mishra RC. 1995. Honey Bees and their Management in India. I.C.A.R., New Delhi, India.
- Morse AA. 1978. *Honey Bee Pests, Predators and Diseases*. Cornell University Press, Ithaca and London.
- Rahman, A. 2017. Apiculture in India, ICAR, New Delhi
- Ribbands CR. 1953. *The Behaviour and Social Life of Honey Bees*. Bee Research Association Ltd., London, UK.
- Rinderer TE. 1986. Bee Genetics and Breeding. Academic Press, Orlando.
- Sardar Singh. 1962. Beekeeping in India. I.C.A.R., New Delhi, India (Reprint: 1982).
- Seeley TD. 1985. Honey Bee Ecology. Princeton University Press, 216 pp.
- Snodgrass RE. 1925. Anatomy and Physiology of the Honey Bee. Mc Graw Hill Book Co., New York & London.
- Snodgrass RE. 1956. *Anatomy of the Honey Bee*. Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York.

ENT 517 Medical and Veterinary Entomology	1+1
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#### Theory

Unit I : Introduction to medical, veterinary and forensic entomology; Classification of Arthropod-borne diseases; Hematophagy, disease transmission and epidemiology; flies (Diptera) of medical and veterinary Importance; moth flies: Leishmaniasis and Bartonellosis; biting midges (Ceratapogonidae).

Unit II : Mosquito taxonomy, biology, and behavior; mosquito viruses: EEE, VEE, SLE, yellow fever,mosquito surveillance; malaria; horse flies, deer flies: EIA, anaplasmosis; muscid flies; Myiasis (Muscoidea); myiasis and louse flies; black flies of medical and veterinary Importance; filariasis: mansonellosis, onchocerciasis.

Unit III : Lice of medical and veterinary importance; rickettsial diseases: epidemic typhus, etc.; mites: rickettsial pox; mites and acariasis: mange, scabies, chiggers; spiders and scorpions; fleas (Siphonaptera) of medical and veterinary importance; plague and murine typhus.

Unit IV : Ticks of medical and veterinary importance; lyme disease, rocky mountain spotted fever, tularemia; true bugs (Hemiptera): kissing bugs and bedbugs; chagas disease; tsetse flies; Lepidoptera and Hymenoptera of medical and veterinary importance.

# Practical

- Identification of arthropod Classes, Orders and Families of medical and veterinary importance;
- Collection, segregation, curing insect and arachnid specimens, their preservation;
- Management of insect and mite pests of medical and veterinary importance;
- Study of some Practicalsaspects in forensic entomology.

## Suggested References

David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6th Edition, Namrutha Publications, Chennai.

Gullan PJ and Cranston PS. 2010. *The Insects: An Outline of Entomology*. 4th Edition, Wiley-Blackwell, West Sussex, UK & New Jersey, US.

Mullen G and Durden L. 2018. Medical and Veterinary Entomology, 3rd Edition, Academic Press.

ENT 518	Lac Culture	1+1
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## Theory

- Unit I : History of lac production; importance, potential of lac production in India; organizations involved in lac production activities; Basic morphology and taxonomy of lac insect, biology of lac insect, strains of lac insects and lac crops distribution, area and production of different strains of lac.
- Unit II : Steps and operation of lac production; lac host plant species, ecological requirements, their cultivation; seasons of host plants, rearing seasons; pruning methods, Selection of brood lac, propagation of lac insects, harvesting of lac, host plant and lac insect pests and diseases; management strategies.
- Unit III : Factors affecting yield and quality of shellac. Pure stock of host plants (kusum, palas, ber, pigeonpea, semialata); Integration of lac cultivation with agro-forestry and horticulture; socioeconomic potential of lac; export-import of lac/ lac products; marketing of lac and its products. Lac processing and value addition; entrepreneurship development.

#### Practical

- Lac host cultivation and lac production practices;
- Equipments for lac production;
- Cultivation of suitable host plants;
- Herbarium of host plants;
- Strains of lac insects;
- Slide preparation of adult and immature stages;
- Inoculation of host tree;

- Molecular characterization of lac insect where possible;
- Harvesting;
- Process of manufacture of seed lac, shell lac from stick lac;

#### **Suggested References**

David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6th Edition, Namrutha Publications, Chennai.

Sharma KK and Ramani S. 2010. Recent advances in lac culture. ICAR-IINRG, Ranchi.

ENT 519	Molecular Approaches in Entomology	2+1
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#### Theory

- Unit I: Introduction to molecular biology, techniques used in molecular biology.
- Unit II : DNA recombinant technology, identification of genes/ nucleotide sequences for traits of interest, techniques of interest in plants and microbes.
- Unit III : Genes of interest in entomological research- marker genes for sex identification, peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Plantderived enzyme inhibitors, protease inhibitors, trypsin inhibitors, á-amylase inhibitors, lectins, terepenes and terpenoids; genes of non-plant origin, *Bacillus thuringiensis* endotoxins, mode of action of cry genes, classification and properties, synthetic Bt toxin genes, Other toxin genes, genes derived from entomophagous viruses, transgenic plants for pest resistance.
- Unit IV : Genetically engineered microbes and parasitoids in biological control-Genetic engineering in baculoviruses and fungal biocontrol agents for greater efficacy against insect pests. Effects of transgenic plants on pest biology and development, resistance management strategies in transgenic crops, molecular mechanism of insecticide resistance.
- Unit V : Genetic-based methods for agricultural insect pest management-insect pest management through sterile insect technique and relase of insects carrying a dominant lethal gene. Methods and application of insect trangenesis, transgenics in silkworm and honeybees. Molecular tools for taxonomy and phylogeny of insectpests, DNA-based diagnostics. Nano technology and its application.

#### Practical

- Isolation of DNA/ RNA;
- Agarose gel electrophoresis of DNA, quantification of DNA by spectrophotometirc and agarose gel analysis, PCR amplification of mitochondrial cytochrome oxidase subunit I gene (cox1) and 16S rRNA gene, cloning of PCR amplicons in standard plasmid vectors for sequencing, confirmation of the insert, miniprep of recombinant plasmid DNA, BLAST analysis and multiple sequence alignment of the sequence with sequences already available in GenBank;
- Isolation of host plant proteins, SDS-PAGE of the isolated proteins.

### **Suggested References**

- Bhattacharya TK, Kumar P and Sharma A. 2007. *Animal Biotechnology*. 1st Ed., Kalyani Publication, New Delhi.
- Hagedon HH, Hilderbrand JG, Kidwell MG and Law JH. 1990. *Molecular Insect Science*. Plenum Press, New York.

- Hoy MA. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2<sup>nd</sup> Ed. Academic Press, New York.
- Oakeshott J and Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer Verlag.
- Rechcigl JE and Rechcigl NA. 1998. *Biological and Biotechnological Control of Insect Pests*. Lewis Publ., North Carolina.
- Roy U and Saxena V. 2007. A Hand Book of Genetic Engineering. 1st Ed., Kalyani Publishers, New Delhi.

Singh BD. 2008. Biotechnology (Expanding Horizons). Kalyani Publishers, New Delhi.

Singh P. 2007. Introductory to Biotechnology. 2nd Ed. Kalyani Publishers, New Delhi.

ENT 520	Plant Quarantine, Bio-Safety and Bio-Security	2+0

## Theory

- Unit I : Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/ diseases and their status.
- Unit II : Plant protection organization in India. Acts related to registration of pesticides and transgenics. Insecticide regulatory bodies, synthetic insecticides, bio-pesticides and pheromone registration procdures. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.
- Unit III : Identification of pest/ disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations; VHT and other safer techniques of disinfestation/ salvaging of infected material.
- Unit IV : WTO regulations; non-tariff barriers; pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; sanitary and phytosanitary measures. Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops.

## **Suggested References**

Rajeev K and Mukherjee RC. 1996. Role of Plant Quarantine in IPM. Aditya Books.

Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental), CRC Press.

Shukla A and Veda OP. 2007. Introduction to Plant Quarantine. Samay Prakashan, New Delhi.

# 1+1

# Theory

- Unit I: Edible and therapeutic insects: the concept, definition, and importance.
- Unit II : History and origin of insects as food, feed and medication; important insect species and insect products consumed.
- Unit III : Edible insect ecology, conservation and management of edible insect resources; environmental opportunities of insect rearing.
- Unit IV : Nutritional composition and role of insects in food security.
- Unit V : Insect farming: the concept, definitions, and rearing techniques.
- Unit VI : Processing edible insects for food and feed.
- Unit VII : Food safety and preservation, edible insects for livelihood security.

## Practical

- Survey and identification of edible and therapeutic insect species;
- Collection and preservation of edible and therapeutic insect specimens;
- Rearing techniques of edible insect species;
- Harvesting techniques of edible insects from natural environment;
- Analysis of proximate elemental composition, antioxidant and anti-nutritional properties and microbial aspects of preservation.

## Suggested References

Halloran A, Flore R, Vantomme P and Roos N 2018. Edible insects in sustainable food systems.

Van Huis A, Itterbeeck JK, Klunder H, Mertens E, Halloran A, Muir G and Vantomme. 2013. Edible insects: future prospects for food and feed security. Food and Agricultural Organization of the United Nations, Rome.

Sl. No.	Course	Course Title	Credit
	No.		hours
Major courses (Minimum 20 Credits)			
1	GPB 501* /	Principles of Genetics	2+1
	MBB 519		
2	GPB 502*	Principles of Plant Breeding	2+1
3	GPB 503*	Fundamentals of Quantitative Genetics	2+1
4	GPB 504	Varietal Development and Maintenance Breeding	1+1
5	GPB 505	Principles of Cytogenetics	2+1
6	GPB 506*	Molecular Breeding and Bioinformatics	2+1
7	GPB 507	Breeding for Quality and Special Traits	2+1
8	GPB 508	Mutagenesis and Mutation Breeding	2+1
9	GPB 509	Hybrid Breeding	1+1
10	GPB 510	Seed Production and Certification	1+1
11	GPB 511	Germplasm Characterization and Evaluation	1+1
12	GPB 512	Genetic Enhancement for PGR Utilization	1+1
13	GPB 513	Breeding Vegetable Crops	2+1
14	GPB 514	Breeding Fruit Crops	2+1
15	GPB 515	Breeding Ornamental Crops	2+1
16	GPB 516	Breeding for Stress Resistance and Climate Change	2+1
17	GPB 571	Qualifying Examination	0+2
18	GPB 581	Seminar-I	0+1
19	GPB 582	Seminar-II	0+1
20	GPB 591	Research	0+27

# **GENETICS AND PLANT BREEDING**

\* Compulsory among major courses

- 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, polygenic inheritance, Meiotic drive, Somatic cell genetics, Haploid Genetics and Genetics of DNA markers, Extra chromosomal inheritance, Genome imprinting.
- 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; Basics, Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression, RNA editing.
- Unit IV : Basics of 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; 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;
- Use of Agrobacterium mediated method and Biolistic gun;
- Visit to transgenic glasshouse and learning the Practicalsconsiderations.

## Suggested References

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 Benzamin/ 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. *PracticalsManual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

GPB 502	Principles of Plant Breeding	2+1

## 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;  $S_1$  and  $S_2$  progeny testing, Progeny selection schemes, Recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding: genetic 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, Participatory and Anticipatory Plant Breeding.

#### Practical

- Floral biology in self and cross pollinated species;
- Selfing and crossing techniques;
- Analysis of variance (ANOVA);
- Estimation of phenotypic and genotypic co-efficient of variation, heritability and genetic advance;
- Maintenance of experimental records;

- Learning techniques in hybrid seed production using male-sterility in horticultural and field crops
- Estimation of different types of heterosis
- Prediction of performance of three way cross and double cross hybrid.
- Prediction of *per se* and test cross performances of inbred lines based on *per se* mid parental and test cross performance
- Theoretical identification of best breeding population ( $F_2$ /backcross) to be used to develop inbred lines for use as pure-line cultivar or in  $F_1$  hybrid development
- Field visits and Practicalsexposure for study of segregating generations in horticultural crops

# Suggested References

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. PracticalsPlant 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.

GPB 503	Fundamentals of Quantitative Genetics	2+1
01000	I undumentally of Quantitative Genetics	

- 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 D<sup>2</sup>, 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.

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.

## **Practicals**

- Analysis and interpretation of variability parameters;
- Analysis and interpretation of Index score and Metroglyph;
- Clustering and interpretation of D<sup>2</sup> 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 tests;
- $L \times T$  analysis and interpretation, QTL analysis;
- Use of computer packages;
- Diallel analysis;
- $\mathbf{G} \times \mathbf{E}$  interaction and Stability analysis.

## **Suggested References**

Bos I and Caligari P. 1995. Selection Methods in Plant Breeding. Chapman & Hall.

Falconer DS and Mackay J. 1998. *Introduction to Quantitative Genetics* (3<sup>rd</sup> Ed.). ELBS/ Longman, London.

Mather K and Jinks JL.1985. *Biometrical Genetics* (3<sup>rd</sup> 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 References* www.iasri.icar.gov.in www.hau.ac.in/OPstat

# GPB 504Varietal Development and Maintenance Breeding1+1

#### Theory

Unit I: Variety Development systems and Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, landraces, hybrid, and population; Variety testing, release and notification systems and norms in India and abroad.

- Unit II: DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties safeguards during seed production.
- Unit III : Maintenance of varieties in self and cross pollinated crops, isolation distance; Principles of seed production; Methods of nucleus and breeder seed production; Generation system of seed multiplication -nucleus, breeders, foundation, and certified.
- Unit IV : Quality seed production technology of self and cross-pollinated crop varieties, *viz.*, Vegetables (tomato, chilli, brinjal, onion, okra, gourds, cucurbits, watermelon, leafy vegetables, cluster bean, dolichos, french bean vegetable soybean, vegetable cowpea, vegetable redgram), Flower and Fruit crops, Plantation, Aromatic crops and Seed spices.
- Unit V : Seed certification procedures; Seed laws and acts, plant variety protection regulations in India: PPV&FRA and international systems: UPOV, ITPGRFA; comparison of both the systems in plant protection

## Practicals

- Identification of suitable areas/ locations for seed production;
- Nucleus seed production;
- Main characteristics of released and notified varieties, hybrids and parental lines;
- PGMS and TGMS;
- Identification of important weeds/ objectionable weeds;
- Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties in different crops;
- Hybrid seed production technology of important crops;
- DUS testing and descriptors in major horticulture crops;
- Variety release proposal formats in different crops.

## **Suggested References**

Agarwal RL. 1997. Seed Technology. 2nd Ed. Oxford & IBH. Kelly AF. 1988. Seed Production of Agricultural Crops. Longman.

- McDonald MB Jr and Copeland LO. 1997. Seed Production: Principles and Practices. Chapman & Hall.
- Poehlman JM and Borthakur D. 1969. Breeding Asian Field Crops. Oxford & IBH. Singh BD. 2005. Plant Breeding: Principles and Methods. Kalyani. 2015 Thompson JR. 1979. An Introduction to Seed Technology. Leonard Hill

GPB 505	Principles of Cytogenetics	2+1
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## Theory

Unit I: Cell cycle, cell cycle regulation and architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; crossing over-mechanisms and theories of crossing over, recombination models; artificial chromosome construction and its uses; Special types of chromosomes. Introduction to techniques for karyotyping; Chromosome banding and painting *-In situ* hybridization (FISH, GISH) and various applications.

- Unit II : Structural and numerical variations of chromosomes and their implications; Evolutionary significance; Symbols and terminologies for chromosome numbers, euploidy, haploids, diploids and polyploids; Utilization of aneuploids in gene location; Variation in chromosome behaviour, somatic segregation and chimeras, endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations, balanced lethal and chromosome complexes; Segregation pattern and inheritance studies in Aneuploids, euploids and polyploidy.
- Unit III : Fertilization barriers in crop plants at pre-and post-fertilization levels; *In-vitro* techniques to overcome the fertilization barriers in crops; Polyploidy- Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid *vs* allopolyploids; Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer; Alien addition and substitution lines, creation and utilization; Apomixis, evolutionary and genetic problems in crops with apomixes.
- Unit IV : Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, *Triticale, Brassica*, and cotton); Hybrids between species with same chromosome number, Alien translocations; Hybrids between species with different chromosome number; Gene transfer using amphidiploids, Bridge species.
- Unit V : Chromosome manipulations in wide hybridization; case studies; Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

## **Practicals**

- Learning the cytogenetical laboratory techniques, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning, *etc.*;
- Microscopy: various types of microscopes;
- Preparing specimen for observation;
- Fixative preparation and fixing specimen for light microscopy studies in cereals;
- Studies on mitosis and meiosis in crop plants;
- Using micrometres and studying the pollen grain size in various crops. Pollen germination *in vivo* and *in-vitro*;
- Demonstration of polyploidy.

## Suggested References

- Becker K and Hardin J. 2004. *World of the Cell*. 5th Ed. Pearson Edu. 9th edition. Carroll M. 1989. *Organelles*. The Guilford Press.
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GPB 506 Molecular Breeding and Bioinformatics 2+1
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#### Theory

- Unit I : Genotyping; Morphological, Biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs, *etc.*), Functional markers; Mapping populations (F<sub>2</sub>s, back crosses, RILs, NILs and DH); Molecular mapping and tagging of agronomically important traits; Concept of linkage, Linkage map construction, Mapping functions (Haldane and Kosambi); Approaches (Single marker, two markers and multiple markers) and analytical tools for QTL mapping; Statistical tools in marker analysis.
- Unit II : Allele mining; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants; F<sub>2</sub> enrichment, Marker-assisted backcross breeding for rapid introgression; Marker-assisted Recurrent selection; 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 crops: Cotton, maize, rice, soybean, oilseeds, tomato, brinjal, chilli, pomegranate, papaya, *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.

#### **Practicals**

- Techniques in plant tissue culture; 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; hardening procedures;
- Visit to commercial micropropagation unit;
- Estimation of linkage between pairs of markers;
- Construction of genetic linkage maps using computer software;

- Approaches and analytical tools for QTL mapping;
- Hands on experience on locus ordering protocols using numerical examples
- Haldane and Kosambi mapping functions
- Transformation using Agrobacterium strains;
- GUS assay in transformed cells/ tissues;
- DNA isolation, DNA purity and quantification tests;
- Gel electrophoresis, gel scoring and data analysis for tagging and phylogenetic relationship;
- NCBI Genomic Resources, GBFF, Swiss Prot, Blast n/ Blast p, Gene Prediction Tool, Expasy Resources, PUBMED and PMC, OMIM and OMIA, ORF finder;
- Familiarity with the use of BLAST and Clustal W tools for DNA sequence analysis
- Comparative Genomic Resources: Map Viewer (UCSC Browser and Ensembl);
- Primer designing- Primer 3/ Primer BLAST.

#### **Suggested References**

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- Chopra VL and Nasim A. 1990. *Genetic Engineering and Biotechnology: Concepts, Methods and Applications*. Oxford & IBH.
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- Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani Publishers, New Delhi. Watson J. 2006. *Recombinant DNA*. Cold Spring harbor laboratory press.

GPB 507	Breeding for Quality and Special Traits	2+1

- 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 quality parameters in vegetables; Keeping quality, nutritional quality, colour, texture, in; tomato, brinjal, chilli, cucurbits, gourds, okra, legume vegetables; Grain quality in rice and its analysis; Golden rice and aromatic rice: Quality protein maize, specialty corns; Breeding strategies, achievements and application in Indian context; Molecular basis of quality traits and their manipulation; Post harvest

manipulation for quality improvement; Characters to be considered and breeding strategies; Molecular and Cytogenetic manipulation for quality improvement.

- Unit III : Breeding for quality improvement in fruits crops; fruit quality traits; Shelf life, nutritional quality; organoleptic quality; TSS, acidity, firmness; Genetic resource management for sustaining nutritive quality in crops.
- Unit IV : Breeding for quality improvement in flower crops; Molecular basis; Genetic manipulation for quality improvement. Rose, chrysanthemum, marigold, gerbera, Jasmine, Breeding for quality improvement in plantation, medicinal and spice crops; Coconut, arecanut, coffee, tea, pepper, cardamom *etc*.
- Unit V : Genetic engineering protocols for quality improvement: Achievements made; Biofortification in crops; Classification and importance, Nutritional genomics and Second generation transgenics.

## Practicals

- Keeping quality evaluation in tomato, pungency and oleoresin in chilli; chips making quality in potato; fruit traits in brinjal; bulb quality in onion; Correlating shelf life and quality improvement;
- Nutritional quality analysis in leafy vegetables, minor fruits;
- Estimation of anti-nutritional factors like oxalates in different varieties/ hybrids: A comparison;
- Quality parameters evaluation in fruit crops;
- Evaluation of quality parameters in flower crops, plantation crops, spice crops and medicinal plants;
- Value addition in crop plants;
- Post-harvest processing of fruit and vegetable 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 traits

## **Suggested References**

- 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.
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- 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.

- Unit I: Mutation and its history, nature and classification of mutations: Spontaneous and induced mutations, micro and macro mutations, pre- and post-adaptive mutations; Detection of mutations. Paramutations in crops plants.
- Unit II : Mutagenic agents: Physical radiation types and sources: Ionizing and non-ionizing radiations. Radiobiology: mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects RBE and LET relationships; Effect of mutations on DNA repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects; Dosimetry -Objects and methods of treatment; Factors influencing mutation: dose rate, acute *v/s* chronic irradiation, recurrent irradiation; Radiation sensitivity and modifying factors: External and internal sources-Oxygen, water content, temperature and nuclear volume.
- Unit III : Chemical mutagens: Classification base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens, their properties and mode of action; Dose determination and factors influencing chemical mutagenesis; Treatment methods using physical and chemical mutagens, Combination treatments; other causes of mutation direct and indirect action, comparative evaluation of physical and chemical mutagens.
- Unit IV : Observing mutagen effects in M<sub>1</sub> generation: plant injury, lethality, sterility, chimeras, *etc.*; Observing mutagen effects in M<sub>2</sub> generation; Estimation of mutagenic efficiency and effectiveness spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, *etc.*; Individual plant based mutation analysis and working out effectiveness and efficiency in M<sub>3</sub> generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies.
- Unit V : Use of mutagens in creating oligogenic and polygenic variations Case studies; *Invitro* mutagenesis Callus and pollen irradiation; Handling of segregating M<sub>2</sub> generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, *etc.*) in different crops; Procedures for micromutations breeding/ polygenic mutations; Achievements of mutation breeding- varieties released across the world, problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING, Base editing, CRISPR/Cas 9.

#### Practicals

- Precautions on handling of mutagens; Dosimetry-Studies of different mutagenic agents: Physical mutagens and Chemical mutagens;
- Learning on Radioactivity- Production source and isotopes at BRIT, Trombay, Learning about gamma chamber;
- Radiation hazards: Monitoring safety regulations and safe transportation of radioisotopes, visit to radio isotope laboratory; learning on safe disposal of radioisotopes;
- Hazards due to chemical mutagens Treating the plant propagules at different doses of physical and chemical mutagens;
- Procedures in combined mutagenic treatments;
- Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature;
- Study of M<sub>1</sub> generation Parameters;
- Study of M<sub>2</sub> generation Parameters;
- Mutation breeding in horticultural and field crops-achievements made and an analysis;
- Mutation breeding vegetatively propagated crops;
- Procedure for detection of mutations for polygenic traits in M<sub>2</sub> and M<sub>3</sub> generations.

Alper T. 1979. Cellular Radiobiology. Cambridge Univ. Press, London.

- Chadwick KH and Leenhouts HP. 1981. The Molecular Theory of Radiation Biology. Springer-Verlag.
- Cotton R, Edkin E and Forrest S. 2000. *Mutation Detection: A PracticalsApproach*. Oxford Univ. Press.
- International Atomic Energy Agency. 1970. *Manual on Mutation Breeding*. International Atomic Energey Agency, Vienna, Italy.
- Shu QY, Forster BP and Nakagawa N. 2012. *Plant Mutation Breeding and Biotechnology*. Gutecnberg Press Ltd. Rome Italy ISBN:978-925107-022-2 (FAO).
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## GPB 509 Hybrid Breeding

1+1

#### 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  $F_2$  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 tomato, chilli, brinjal, okra, cucurbits, watermelon, carrot, cabbage, papaya, marigold.

# Practicals

- 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 horticultural 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 various horticultural crops—an account on the released hybrids, their potential, problems and ways of overcoming it;
- Hybrid breeding at National and International level, opportunities ahead.

# **Suggested References**

- Agarwal RL. 1998. Fundamental of Plant Breeding and hybrid Seed Production. Science Publisher London.
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- 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.

- Unit I : Importance of seed as basic input in agriculture; Seed quality concept and importance; Generation system of seed multiplication -Varietal replacement rate, Seed multiplication ratios, Seed replacement rate, Seed renewal period and seed demand and supply; Various factors influencing seed production –Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration.
- Unit II : Nucleus seed production and its maintenance Maintenance of parental lines of hybrids, Production of breeder, foundation and certified seed and their quality maintenance; Principles of seed production in self- and cross-pollinated crops; Hybrid seed production
   - system and techniques involved in Seed village concept; Organic seed production and certification.
- Unit III : Principles of seed production in horticultural crops; Floral structure, pollination mechanism and seed production techniques in self- and cross-pollinated crops; Solanaceous vegetables; Cucurbits; Gourds
- Unit IV: Floral structure, pollination mechanism and methods and techniques of seed production in legume vegetables; Varietal and hybrid seed production techniques in major plantation, aromatic and spice crops.
- Unit V: Floral structure, pollination mechanism and methods and techniques of seed production in major commercial flower crops. Hybrid-seed production techniques in major vegetatively propagated crops.
- Unit VI: Seed certification history, concept, objectives; Central seed certification board Seed certification agency/ organization and staff requirement; Legal status Phases of seed certification, formulation, revision and publication of seed certification standards; Minimum Seed Certification Standards (MSCS) for different crops General and specific crop standards, Field and seed standards; Planning and management of seed certification programs; Eligibility of a variety for certification, area assessment, cropping history of the seed field.

- Planting design for variety- hybrid seed production techniques, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony;
- Identification of rogues and pollen shedders, supplementary pollination, detasseling, hand emasculation and pollination;
- Pollen collection and storage methods, pollen viability and stigma receptivity;
- Pre-harvest sanitation, maturity symptoms, harvesting techniques;
- Visits to seed production plots visit to seed industries;
- Planning for seed production: cost benefit ratio, seed multiplication ratio and seed replacement rate;
- General procedure of seed certification, identification of weed and other crop seeds as per specific crops, field inspection at different stages of a crop and observations recorded on contaminants and reporting of results, inspection and sampling, harvesting/ threshing, processing and after processing for seed law enforcement;
- Specifications for tags and labels to be used for certification purpose.

- Agrawal PK and Dadlani M. 1987. *Techniques in Seed Science and Technology*, South Asian Publishers, Delhi.
- Agrawal RL. 1997. Seed Technology, Oxford & IBH Publishing.
- Anon, 1965. *Field Inspection Manual and Minimum Seed Certification Standards*, NSC Publication, New Delhi.
- Anon. 1999. *Manual of Seed Certification procedures*. Directorate of Seed Certification, Coimbatore, Tamil Nadu.
- Joshi AK and Singh BD. 2004. *Seed Science and Technology*, Kalyani Publishers, New Delhi. Kelly AF. 1988. *Seed Production of Agricultural Crops*. John Wiley, New York.
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- Singhal NC. 2003. *Hybrid Seed Production in Field Crops*, Kalyani Publications, New Delhi Tunwar NS and Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, New Delhi.
- *e-Resources* www.gov.mb.ca www.agricoop.nic.in www.agri.nic.in www.fao.org www.seednet.gov.in

GPB 511	Germplasm Characterization and Evaluation	1+1
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#### Theory

- Unit I: Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; Germplasm characterization/ evaluation procedures; Evaluation of germplasm for specific traits; Measuring diversity using agro-morphological data, markers and their use in PGR, evaluation of biotic and abiotic stresses; Principles and methods for formulating core and mini core collections and their validation; Web based tools for management of data.
- Unit II : Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; Maintaining sufficiently large populations for effective conservation of farmer landraces; Evaluation and maintenance of wild relatives of crop plants; Genetic enhancement, Use of CWRs genetic resources for crop improvement.
- Unit III : High throughput phenotyping systems- imaging and image processing concepts for automated germplasm characterization (phenotyping);Evaluation for nutritional traits, resistance traits.

- Field layout and experimental designs;
- Recording field data on germplasm evaluation in different agri-horticultural crops,
- post harvest handling;
- Evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm, data processing;
- Documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing,

- Brown AHD, Clegg MT, Kahler AL, Weir BS (eds.) 1990. Plant Population Genetics, Breeding, and Genetic Resources, Sinauer Associates, USA.
- Frankel R and Galun E 1977. Pollination Mechanisms, Reproduction and Plant Breeding. Monographs on Theoretical and Applied Genetics, Springer-Verlag, Berlin, Heidelberg.
- Hayward MD, Bosemak NO and Romagosa I. 1993. *Plant Breeding: Principles and Practices*, Chapman & Hall.
- Holden JHN and Williams JT 1984. Crop genetic resources: conservation and evaluation, IBPGR.
   Puzone, L and Th. Hazekamp 1996. Characterization and Documentation of Genetic Resources

Utilizing Multimedia Database. NBPGR, New Delhi.

- Rana RS, Sapra RL, Agrawal RC and Gambhir R 1991. Plant Genetic Resources, *Documentation and Information Management*. NBPGR, New Delhi.
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- Sundeep Kumar, et al. 2016. Evaluation of 19,460 wheat accessions conserved in the Indian national genebank to identify new sources of resistance to rust and spot blotch diseases. PloS One Vol 11, pages 0167702.
- Tripathi K, Bhardwaj R, Bhalla S, Kaur V, Bansal R, Yadav R, Gangopadhyay KK, Kumar A and Chaudhury R. 2018. *Plant Genetic Resources Evaluation: Principles and Procedures*, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi. vi+50 p.

GPB 512	Genetic Enhancement for PGR Utilization	1+1
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#### Theory

- Unit I : Concepts of gene pools; Introduction, potential of pre-breeding; Role of crop wild relatives, semi exotics, creating and managing variation; Basic concepts to set up a successful pre-breeding programme.
- Unit II : Understanding crop adaptation, handling and maintenance of CWRs; Synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments; Role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm; Identifying desirable traits in natural populations, screening for biotic and abiotic stress resistance traits; Screening of nutritionally important traits, genetic analysis to understand the inheritance of novel traits.
- Unit III :Parental selection for pre-breeding, search for superior genotypes, breeding methods for trait transfer; moving the genes unadapted to adapted, wide hybridization, Incongruity and its management, modern tools for incongruity management; Cytogenetical approaches for gene transfer such as alien addition and substitution; Segregating populations and their management in wide crosses, purging the undesirable traits, testing and improving the adaptability of wide cross derivatives; Cytological studies, florescence microscopy, embryo rescue methods, pollen physiology and storage, pollen storage methods to facilitate wide hybridization; Pre- and post-zygotic barriers.

- Characterization of CWRs by visiting the fields;
- Screening methods for special traits-biotic and abiotic resistance;
- Screening for nutritional traits;

- Crossability studies in CWRs of cereals, legumes, oilseeds, vegetables;
- Assessment of pre and post-zygotic barriers in wide hybridization crosses;
- Pollen storage studies;
- Special requirements for growing CWRs, inducing flowering by manipulating day length, temperature, chemical spraying, *etc*.

Andey Pereira. 2006. Plant Reverse Genetics, Methods and Protocols, Humana Press

- Bisht *et al.* 2004. Broadening the genetic base of sesame (*Sesamum indicum* L.) through genetic enhancement. *Plant Genetic Resources*, 2(3): 143–151.
- Dale JW and von Schantz M. 2007. From genes to genomes. Concepts and applications of DNA technology. John Wiley & Sons Ltd., Chichester, England.

Duvick DN. 1990. Genetic enhancement and plant breeding. p. 90–96. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland.

Goodman, RM. 2004. *Encyclopedia of plant and crop science*. Marcel Dekker Inc., Switzerland. Kimber, G and Feldman, M. 1987. *Wild Wheat: An introduction*. Special report 353, College of Agriculture, University of Missouri-Columbia.

Lynch M. and Walsh B. 1998. *Genetics and analysis of quantitative traits*. Sinauer Associates Inc., MA, USA.

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- Ramanatha Rao V, Brown AHD, Jackson M. 2001. *Managing Plant Genetic Diversity*. CABI publication.
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Yunbi Xu. 2010. Molecular plant breeding, CABI publishers

*e-Resources* <u>http://www.integratedbreedPlaning.net/</u> pre-breeding-effective-use-plant-geneticresources <u>http://www.croptrust.org/</u> <u>http://www.bioversityinternational.org/</u> <u>training/training\_materials/pre\_breeding.htm</u>

http://www.grdc.com.au/director/research/prebreeding

http://www.grdc.com.au/director/research/prebreeding

GPB 513	Breeding Vegetable Crops	2+1

# Theory

Unit I: Breeding for Leafy vegetables: Amaranth, fenugreek, chenopods and lettuce.

Unit II : Breeding for Cucurbits: Gourds, melons, pumpkins and squashes.

- Unit III : Breeding for Solanaceae: Potato and tomato, eggplant, hot pepper, sweet pepper
- Unit IV : Breeding for Cole crops: Cabbage, cauliflower, broccoli and knolkhol.

Breeding for Root vegetables: Carrot, beetroot, radish, sweet potato and tapioca.

Unit V : Breeding for other vegetable crops: Peas, beans, onion, garlic and okra.

- Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm;
- Hybridization and handling segregating generations;
- Induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops;

- Hybrid seed production of vegetable crops in bulk;
- Screening techniques for insect-pests, disease and environmental stress resistance in vegetable crops;
- Demonstration of sib-mating and mixed population;
- Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques;
- Visit to breeding blocks, MAS for incorporating traits governed by major and polygenes.

Allard RW. 1999. Principles of Plant Breeding. John Wiley & Sons.

- Fageria MS, Arya PS and Choudhary AK. 2000. *Vegetable Crops: Breeding and Seed Production*. Vol. I. Kalyani Publishers, New Delhi.
- Kalloo G. 1988. Vegetable Breeding. Vols. I-III. CRC Press.
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- Rai N and Rai M. 2006. *Heterosis Breeding in Vegetable Crops*. New India Publication Agency. Ram HH. 2005. *Vegetable Breeding-Principles and Practices*. Kalyani Publishers
- Sharma JP. 2010. Principles of Vegetable Breeding. Kalyani Publishers, New Delhi.

Singh BD. 1983. Plant Breeding. Kalyani Publishers

GPB 514	Breeding Fruit Crops	2+1

# Theory

- Unit I: Fruit crop breeding: History, importance of fruit breeding, centers of diversity, distribution, domestication and adaptation of commercially important fruits.
- Unit II : Issues in fruit crop breeding; –Heterozygosity, polyploidy, polyembryony, parthenocarpy and seed lessness, incompatibility and sterility systems.
- Unit III : Apomixis merits and demerits, types, variability for economic traits, role of genetic engineering and biotechnology in improvement of fruit crops.
- Unit IV : Crop improvement in mango, banana, citrus, grapes, papaya, sapota and pomegranate, pineapple and guava, apple and other rosaceous crops and region specific fruit crops.

# Practicals

- Germplasm documentation;
- Floral biology of mango, guava, citrus, grape, pomegranate, pollen viability in major fruit crops;
- Pollen germination to study time of anthesis and stigma receptivity;
- Hybridization technique in important fruit crops, hybrid seed collection and raising;
- Colchicine treatment for induction of polyploidy;
- Exposure to resistance breeding and screening techniques;
- Mutation breeding practices raising and evaluation of segregating populations;
- Use of mutagens to induce mutations and polyploidy;
- Visit to Biotechnology Lab and study of *in-vitro* breeding techniques.

# **Suggested References**

Bhojwani SS and Razdan MK. 2006. *Plant Tissue Culture -Theory and Practice*. Elsevier Publication, Amesterdam.

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- Chadha KL and Shikhamany SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House, New Delhi.
- Janick and Moore JN. 1996. *Advances in Fruit Breeding*, AVI Pub., USA. Janick J and Moore JN. 1996. *Fruit Breeding*. Vols. I to III. John Wiley & Sons.
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- Ray PK. 2002. Breeding of Tropical and Sub-tropical Fruits. Narosa Publishing House, New Delhi.

Simmonds NW. 1976. Evolution of Crop Plants, Orient Longman, London.

GPB 515	Breeding Ornamental Crops	2+1
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#### Theory

- Unit I : History of improvement of ornamental plants; Centre of origin of ornamental crop; Objectives and techniques in ornamental plant breeding.
- Unit II : Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops, viz., Rose, Jasmine, Chrysanthemum, Tuberose, Gerbera, Gladiolus, Dahlia, Lilium, Gaillardia, Petunia, Bouganvillea, Pansy, Marigold, Geranium, Antirrhinum, China aster, Orchids, Carnation, Hibiscus, etc.
- Unit III : Development of promising cultivars of important ornamental and flower crops; Role of Heterosis and its exploitation, production of  $F_1$  hybrids and utilization of male sterility.
- Unit IV: Production of open pollinated seeds, harvesting, processing and storage of seeds; Seed certification.

# Practicals

- Study of floral biology and pollination in important species and cultivars of ornamental crops;
- Techniques of inducing polyploidy and mutation;
- Production of pure and hybrid seed;
- Methods of breeding suited to seed propagated plants;
- Polyploidy and mutations to evolve new varieties;
- Breeding methods for biotic and abiotic stresses;
- Visit to research institutes involved in ornamental crop breeding.

# **Suggested References**

- Alexander V. 2002. *Breeding for ornamentals: Classical and Molecular Approaches*. Kluwer Academic Publishers, London.
- Allard RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons. INC. New York. Bhattacharjee SK and De LC. 2003. *Advanced Commercial Floriculture* Vol. 1. Aavishkar Publishers & Distributors, Jaipur.

- Bose TK and Yadav LP. 2003. *Commercial Flowers*. Naya Prokash Publishers, Kolkata. Chadha KL and Bhattacharjee SK. *Advances in Horticulture* Vol. 12, Malhotra Publishing House, New Delhi.
- Mc Donald MB and Kwong FY. 2005. *Flower Seeds Biology and Technology*, CABI Publishing, Oxfordshire, UK.

Watts L.1980. Flower and Vegetable Plant Breeding. Grower Books

GPB 516	Breeding for Stress Resistance and Climate Change	2+1	
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#### 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; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/ contaminants in soil, water and environment.
- Unit V : Crop wild relatives as a source of resistance to biotic and abiotic factors in major horticultural crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

- 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;
- Quality parameters evaluation.

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.

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.

# PLANT PATHOLOGY

Sl.	Course	Course Title	Credit
No.	No.		Hours
Major o	courses (Minim	num 20 Credits)	
1	PAT 501*	Mycology	2+1
2	PAT 502*	Plant Virology	1+1
3	PAT 503*	Plant Pathogenic Prokaryotes	1+1
4	PAT 504*	Plant Nematology	1+1
5	PAT 505*	Principles of Plant Pathology	2+1
6	PAT 506*	Techniques in Detection and Diagnosis of Plant Diseases	0+1
7	PAT 507	Principles of Plant Disease Management	2+1
8	PAT 508	Epidemiology and Forecasting of Plant Diseases	1+0
9	PAT 509	Disease Resistance in Plants	2+0
10	PAT 510	Ecology of Soil-borne Plant Pathogens	1+1
11	PAT 511	Chemicals and Botanicals in Plant Disease Management	1+1
12	PAT 512	Detection and Management of Seed borne Pathogens	1+1
13	PAT 513	Biological Control of Plant Diseases	1+1
14	PAT 514	Integrated Disease Management	2+1
15	PAT 515*	Diseases of Field and Medicinal Crops	2+1
16	PAT 516	Diseases of Fruits, Plantation and Ornamental Crops	2+1
17	PAT 517	Diseases of Vegetable and Spices Crops	2+1
18	PAT 518	Post harvest Diseases	1+1
19	PAT 519	Plant Quarantine and Regulatory Measures	1+0
20	PAT 520	Insect Vectors of Plant Viruses and other Pathogens	1+1
21	PAT 521	Mushroom Production Technology	1+1
22	PAT 571	Qualifying Examination	0+2
23	PAT 581	Seminar-I	0+1
24	PAT 582	Seminar-II	0+1
25	PAT 591	Research	0+27

\* Compulsory among major courses

PAT 501 Mycology 2+1	
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- UNIT I : Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs. History of mycology. Importance of culture collection and herbarium of fungi. Somatic characters and reproduction in fungi. Modern concept of nomenclature and classification, Classification of kingdom fungi: Stramenopila and Protists.
- UNIT II : The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota. Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.
- UNIT III : Kingdom fungi: General characters, mode of reproduction, ultrastructure and life cycle patterns in representative genera under Chytridiomycota, Zygomycota, Ascomycota: Archiascomycetes, Ascomycetousyeasts, Pyrenomycetes, Plectomycetes, Discomycetes, Loculoascomycetes, Erysiphales and anamorphs of ascomycetous fungi.
- UNITIV :Basidiomycota; general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes. Uridinales and Ustilaginales; variability, host specificity and life cyclepattern in rusts and smuts. Mitosporic fungi; status of asexual fungi, their teliomorphic relationships, Molecular characterization of plant pathogenic fungi.

## Practicals

Detailed comparative study of different groups of fungi: live specimens, Collection, preservation, culturing and identification of plant parasitic fungi. Saccardoan classification and classification based on conidiogenesis. Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi. Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and athalia. Oomycota: somatic and reproductory structures of *Pythium, Phytophthora*, downy mildews and Albugo, Zygomycetes: Sexual and asexual structures of *Mucor, Rhizopus*, General characters of VAM fungi. Ascomycetes: fruiting structures, Erysiphales, and Eurotiales; general identification characters of Pyrenomycetes, Discomycetes, Loculoascomycetes and Laboulbeniomycetes. Basidiomycetes: characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic states. Application of molecular approaches and techniques for identification of fungal pathogens.

## **Suggested Referencess**

- Ainsworth G C, Sparrow F K & Susman H S.1973. *TheFungi–An Advanced Treatise*. Vol. IV (A&B). Academic Press, New York.
- Alexopoulos C J, Mims CW & Blackwell M.2000. *Introductory Mycology*. 5th Ed. John Wiley & Sons, New York.
- Dube H C 2019 An Introduction to Fungi 4th Edition, Scientific Publisher
- Maheshwari R 2016. Fungi: Experimental Methods in Biology 2nd edn. CRC Press, US.
- Mehrotra R S & Arneja KR.1990. *An Introductory Mycology*. Wiley Eastern, New Delhi. Sarbhoy A K.2000. *Text book of Mycology*. ICAR, New Delhi.
- Singh R S.1982. PlantPathogens The Fungi. Oxford & IBH, New Delhi.

Webster J.1980. Introduction to Fungi. 2<sup>nd</sup> Ed. Cambridge Univ. Press, Cambridge, New York.

Yousuff Gherbawy and Kerstin Voigt S. 2010. Molecular identification of fungi. Springers

PAT 502	Plant Virology	1+1
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- UNIT I :History and economic significances of plant viruses. General and morphological characters, composition and structure of viruses. Myco-viruses, arbo and baculo viruses, satellite viruses, satelliteRNAs, phages, viroids and prions. Origin and evolution of viruses and their nomenclature and classification (as per ICTV)
- UNIT II :Genome organization, replication in selected groups of plant viruses and their movement in host. Response of the host to virus infection: biochemical, physiological, and symptomatical changes. Transmission of viruses and virus-vector relationship. Isolation and purification of viruses. Density gradient centrifugation and Electron microscopy.
- UNIT III :Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques. Natural (R-genes) and engineering resistance to plant viruses.
- UNIT IV :Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival). Management of diseases caused by plant viruses.

# Practicals

Study of symptoms caused by plant viruses (followed by field visit). Isolation and biological purification of plant virus cultures. Bioassay of virus cultures on indicator hosts and host differentials. Transmission of plant viruses (Mechanical, graft and vector and study of disease development). Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology. Antisera production, Detection and diagnosis of plant viruses with serological (ELISA, DIBA, Western blotting and Lateral flow micro array), nucleic acid (Non-PCR–LAMP, NGS& PCR based techniques). Exposure to basic bioinformatic tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bio edit tool, Clastal X/W, MEGA Software and RDP).

#### **Suggested Referencess**

Bos L.1964. Symptoms of Virus Diseases in Plants. Oxford & IBH., New Delhi.

- Brunt A A, Krabtree K, Dallwitz M J, Gibbs A J & Watson L. 1995. *Virus of Plants: Descriptions and Lists from VIDE Database*. CABI, Wallington.
- Gibbs A & Harrison B.1976. PlantVirology-ThePrinciples. Edward Arnold, London.
- Roger Hull 2002. Mathew's Plant Virology.4th Ed. Academic Press, New York.

Roger Hull- 2009. Comparative Plant Virology, 2nd Edition, Publisher. Elsevier

Noordam D. 1973. Identification of Plant Viruses, Methods and Experiments. Oxford & IBH, NewDelhi.

WilsonC, 2014. Applied Plant Virology. CABI Publishing England.

David G. A. Walkey, 1990- Applied Plant Virology, Springer Science Business media Publisher

PAT 503	Plant Pathogenic Prokaryotes	1+1

#### Theory

UNIT I :Prokaryotic cell: History and development of Plant bacteriology, history of plant bacteriology in India. Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins. Structure of bacterial cell. Structure and composition of gram negative and grampositive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccharide structure; Membrane transport; fimbriae and pili (Type IV pili); Mechanism of flagellar rotatory motor locomotion, and bacterial movement; Glycocalyx (S-layer; capsule); the bacterial chromosomes and plasmids; Operon and other structures in cytoplasm; Morphological feature of fastidious bacteria, Spiroplasmas and Phytoplasmas.

- UNIT II :Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopathogenic prokaryotes.
- UNIT III :Taxonomy of phytopathogenic prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma. The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes.
- UNIT IV :Variability among phytopathogenic prokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria-conjugation; transformation; transduction); and horizontal gene transfer.
- UNIT V :Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle; Classification of phages, use of phages in plant pathology/bacteriology, Lysogenic conversion; H Plasmids and their types, plasmid borne phenotypes. Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.

# Practicals

Study of symptoms produced by phytopathogenic prokaryotes. Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria. Growth and measurement. Stains and staining methods. Biochemical and serological characterization. Isolation of genomic DNA plasmid. Use of antibacterial chemicals/antibiotics. Isolation of fluorescent *Pseudomonas*. Preservation of bacterial cultures. Identification of prokaryotic organisms by using 16S rDNA, and other gene sequences. Diagnosis and management of important diseases caused by bacteria and mollicutes.

# **Suggested Referencess**

Goto M.1990. Fundamentals of Plant Bacteriology. Academic Press, New York.

Jayaraman J & Verma J P. 2002. *Fundamentals of Plant Bacteriology*. Kalyani Publ., Ludhiana.

- Jeevan P Varma, @006, The Bacteria, Malhotra Publishing House
- Mount M S & Lacy G H.1982. *Phytopathogenic Prokaryotes*. Vols. I, II Academic Press, New York.

Salle A J 1979. Fundamental Principles of Bacteriology 7<sup>th</sup>edn.

Kalyan K Mondal, 2011, Plant Bacteriology, Kalyani Publications

Verma J P, Varma A & Kumar D. (Eds).1995. Detection of Plant Pathogens and their Management. Angkor Publ., New Delhi.

rA1 504 Flant Nematology 1+1
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#### Theory

UNIT I :Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology; nematode habitats and diversity-plant, animal and human parasites; beneficial nematodes; economic importance of nematodes to agriculture, horticulture and forestry

- UNIT II :Gross morphology of plant parasitic nematodes; anatomy (body systems), broad classification, nematode biology, physiology and ecology.
- UNIT III :Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.
- UNIT IV: Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes.
- UNIT V :Principles and practices of nematode management; integrated nematode management.
- UNIT VI :Emerging nematode problems, Importance of nematodes in international trade and quarantine.

# Practicals

Studies on kinds of nematodes- free-living, animal, insect and plant parasites; nematode extraction from soil; extraction of migratory endoparasites, staining for sedentary endoparasites; examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology. perennial pattern in RKN, semi-permanent mounts, dry/wet preservation methods of nematode infected plant specimen

# Suggested Referencess

Dropkin V. H., 1980. An Introduction to Plant Nematology. John Wiley & Sons, New York. Maggenti A.R., 1981. General Nematology. Springer-Verlag, New York.

- P Parvatha Reddy 2019. Introductory Plant Nematology, Scientific Publishers
- Perry R.N.& Moens M., 2013. Plant Nematology. 2ndEd. CABI Publishing: Wallingford, UK.
- Perry R. N., Moens M., & Starr, J L.2009.*Root- knot nematodes*, CABI Publishing: Wallingford, UK.
- Ravichandra, N. G., 2008. Plant Nematology. IK International, New Delhi, India
- Sikora R A, Coyne D, Hallman J and Timper P, 2018. *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture*. 3rdedn. CABI Publishing, England.
- Thorne G.1961. *Principles of Nematology*. McGrawHill, New Delhi.
- Walia R.K & Bajaj H.K., 2003. Text Book on Introductory Plant Nematology. ICAR, New Delhi.
- Walia R.K. & Khan M.R., 2018. A Compendium of Nematode Diseases of Crop Plants, ICAR-AICRP(Nematodes), IARI, New Delhi.

PAT 505	Principles of Plant Pathology	2+1
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- UNIT I :Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.
- UNIT II :Growth, reproduction, survival and dispersal of important plant pathogens, role of environment and host nutrition on disease development.
- UNIT III :Host parasite interaction, recognition concept and infection, symptomatology, disease development-role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolisms affected by plant pathogens.
- UNIT IV :Genetics of resistance; 'R'genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance.

# Practicals

Basic plant pathological techniques. Isolation, inoculation and purification of plant pathogens and proving Koch's postulates. Techniques to study variability in different plant pathogens. Purification of enzymes, toxins and their bioassay. Estimation of growth regulators, phenols, phytoalexins in resistant and susceptible plants.

# Suggested Referencess

Agrios G N. 2005. Plant Pathology. 5th Ed. Academic Press, New York.

- Heitefuss R & Williams P H .1976. *Physiological Plant Pathology*. Springer Verlag, Berlin, New York.
- Mehrotra R S & Aggarwal A. 2003. Plant Pathology. 2ndEd. Oxford & IBH, New Delhi.
- Singh R S 2017. Introduction to Principles of Plant Pathology. 5thedn. MedTech, New Delhi.
- Singh R P 2012. *PlantPathology* 2<sup>nd</sup>edn. Kalyani Publishers, New Delhi.
- Singh D P & Singh A. 2007. Disease and Insect Resistance in Plants. Oxford & IBH, New Delhi.
- Upadhyay R K & Mukherjee K G. 1997. *Toxins in Plant Disease Development and Evolving Biotechnology*. Oxford & IBH, New Delhi.

PAT 506	Techniques in Detection and Diagnosis of Plant Diseases	0+1
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# Practical

Detection of plant pathogens 1. based on visual symptoms, 2. Biochemical test 3. Using microscopic techniques, 4. Cultural studies; (use of selective media to isolate pathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serological assays 7. Nucleic acid-based techniques (Non-PCR–LAMP, Lateral flow microarray & PCR based- multiplex, nested, qPCR, immune capture PCR, *etc.*). Phenotypic and genotypic tests for identification of plant pathogens. Molecular identification (16SrDNA and 16s-23S rDNA intergenic spacer region sequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing. Volatile compounds profiling by using GC-MS and LC-MS. FAME analysis, Fluorescence in-situ Hybridization (FISH), Flow Cytometry, Phage display technique, biosensors for detection of plant pathogens. Genotypic tools such as genome/specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

# **Suggested Referencess**

- Baudoin A B A M, Hooper G R, Mathre D E & Carroll R B. 1990. Laboratory Exercises in *Plant Pathology: An Instructional Kit.* Scientific Publ., Jodhpur.
- Dhingra O D & Sinclair J B. 1986. Basic Plant Pathology Methods. CRCPress, London, Tokyo. Fox RTV. 1993. Principles of Diagnostic Techniques in Plant Pathology, CABI Wallington.
- Mathews R E F. 1993. Diagnosis of Plant Virus Diseases. CRCPress, BocaRaton, Tokyo.
- Pathak V N. 1984. Laboratory Manual of Plant Pathology. Oxford & IBH, New Delhi.
- Forster D & Taylor S C. 1998. *Plant Virology Protocols: From Virus Isolation to Transgenic Resistance. Methods in Molecular Biology*. Humana Press, Totowa, New Jersey.
- Matthews R E F.1993. Diagnosis of Plant Virus Diseases. CRCPress, Florida.
- Noordam D.1973. Identification of Plant Viruses, Methods and Experiments. Cent. Agic. Pub. Doc. Wageningen.

Trigiano R N, Windham M T & Windham AS. 2004. *Plant Pathology-Concepts and Laboratory Exercises*. CRCPress, Florida.

Chakravarti B P.2005. Methods of Bacterial Plant Pathology. Agrotech, Udaipur.

PAT 507	Principles of Plant Disease Management	2+1

#### Theory

- UNIT I : Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanical methods of plant disease control, integrated control measures of plant diseases. Disease resistance and molecular approach for disease management.
- UNIT II :History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Label claim of fungicides.
- UNIT III : Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants, health *vis-a-vis* environmental hazards, residual effects and safety measures

#### Practicals

Phytopathometry. Methods of *in vitro* evaluation of chemicals, antibiotics, bio agents against plant pathogens. Field evaluation of chemicals, antibiotics, bio agents against plant pathogens. Soil solarization, methods of soil fumigation under protected cultivation. Methods of application of chemicals and bio control agents. ED and MIC values, study of structural details of sprayers and dusters. Artificial epiphytotic and screening of resistance.

#### **Suggested Referencess**

Fry WE. 1982. Principles of Plant Disease Management. Academic Press, New York.

- Hewitt HG. 1998. *Fungicides in Crop Protection*. CABI, Wallington. Marsh RW. 1972. Systemic Fungicides. Longman, New York.
- Nene YL & Thapliyal PN. 1993. Fungicides in Plant Disease Control. Oxford & IBH, New Delhi. Palti J. 1981. Cultural Practices and Infectious Crop Diseases. Springer Verlag, New York.
- Vyas SC. 1993 Handbook of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

PAT 508	Epidemiology and Forecasting of Plant Diseases	1+0	
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- UNIT I :Epidemic concepts, simple interest and compound interest disease, historical development. Elements of epidemics and their interaction. Structures and patterns of epidemics. Modelling, system approaches and expert systems in plant pathology.
- UNIT II :Genetics of epidemics. Models for development of plant disease epidemics. Common and natural logarithms, function fitting, area under disease progress curve and correction factors, inoculum dynamics. Population biology of pathogens, temporal and spatial variability in plant pathogens.
- UNIT III :Epidemiological basis of disease management. Survey, surveillance and vigilance. Remote sensing techniques and image analysis. Crop loss assessment.
- UNIT IV :Principles and pre-requisites of forecasting systems and factors affecting various components of forecasting, some early forecasting and procedures based on weather and inoculum potential, modelling disease growth and disease prediction. Salient features of important forecasting models.

- Campbell C L & Madden L V. 1990. *Introduction to Plant Disease Epidemiology*. John Wiley & Sons, New York
- Cooke B, Jones D M and Gereth K B 2018. *The Epidemiology of Plant Diseases*. Springer Publications. Cowling EB & Horsefall JG. 1978. *Plant Disease*. Vol. II. Academic Press, New York.
- Laurence V M, Gareth H & Frame Van den Bosch (Eds.). *The Study of Plant Disease Epidemics*. APS, St. Paul, Minnesota.
- Nagarajan S & Murlidharan K. 1995. Dynamics of Plant Diseases. Allied Publ., New Delhi.
- Thresh J M. 2006. *Plant Virus Epidemiology*. Advances in Virus Research 67, Academic Press, New York.
- Van der Plank J E. 1963. Plant Diseases Epidemics and Control. Academic Press, New York.
- Zadoks JC & Schein RD. 1979. *Epidemiology and Plant Disease Management*. Oxford Univ. Press, London.

PAT 509	Disease Resistance in Plants	2+0
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#### Theory

- UNIT I :Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centers as sources of resistance, disease resistance terminologies. Disease escape, non-host resistance and disease tolerance.
- UNIT II :Genetic basis of disease resistance, types of resistance, identification of physiological races of pathogen, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.
- UNIT III : Host defence system, morphological and anatomical resistance, pre-formed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms. Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment.

#### **Suggested Referencess**

- Deverall B J. 1977. *Defence Mechanisms in Plants*. Cambridge Univ. Press, Cambridge, New York. Mills Dallice *et al.*1996. *Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction*. APS, St Paul, Minnesota.
- Parker J. 2008. *Molecular Aspects of Plant Diseases Resistance*. Blackwell Publ. Robinson RA. 1976. *Plant Pathosystems*. Springer Verlag, New York.
- Singh BD. 2005. Plant Breeding Principles and Methods. 7th Ed. Kalyani Publ., Ludhiana.
- Van der Plank J E. 1975. Principles of Plant Infection. Academic Press, New York.
- Van der Plank J E. 1978. *Genetic and Molecular Basis of Plant Pathogenesis*. Springer Verlag. New York.
- Van der Plank J E. 1982. Host Pathogen Interactions in Plant Disease. Academic Press, New York. Van der Plank J E. 1984. Disease Resistance in Plants. Academic Press, New York.

- UNIT I :Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates for soil and root inhabiting fungi. Interaction of soil borne microorganisms.
- UNIT II : Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis. Conducive and suppressive soils.
- UNIT II : Biological control- concepts and potentialities for managing soil borne pathogens. Potential of *Trichoderma* and fluorescent *Pseudomonas* in managing plant diseases.

#### Practical

Quantification of rhizosphere and rhizoplane microflora with special emphasis on pathogens; pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils; suppression test for soil- borne pathogens by antagonistic microorganisms. Isolation and identification of different biocontrol agents. Study of various plant morphological structures associated with resistance, testing the effect of root exudates and extracts on spore germination and growth of plant pathogens. Estimating the phenolic substances, total reducing sugars in susceptible and resistant plants. Estimating the rhizosphere and root tissue population of microorganisms (pathogens) in plants.

#### **Suggested Referencess**

- Baker K F & Snyder W C. 1965. Ecology of Soil-borne Plant Pathogens. John Wiley, New York. Cook R J & Baker K F. 1983. The Nature and Practice of Biological Control of Plant Pathogens. APS, St Paul, Minnesota.
- Garret SD. 1970. Pathogenic Root-infecting Fungi. Cambridge Univ. Press, Cambridge, New York. Hillocks RJ & Waller JM. 1997. Soil-borne Diseases of Tropical Crops. CABI, Wallington.
- Mondia J L and Timper P 2016. Interactions of microfungi and plant parasitic nematodes. In:*Biology of Microfungi* (De-Wei-Lei Ed.). Springer Publications
- Parker C A, Rovira A D, Moore K J & Wong PTN. (Eds). 1983. *Ecology and Management of Soil-borne Plant Pathogens*. APS, St. Paul, Minnesota.

PAT 511 Chemicals and Botanicals in Plant Disease Management 1+	+1
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- UNIT I :History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals and botanicals.
- UNIT II : Classification of chemicals used in plant disease management and their characteristics.
- UNIT III : Chemicals in plant disease control, *viz.*, fungicides, bactericides, nematicides, antiviral chemicals and botanicals. Issues related to label claim.
- UNIT IV: Formulations, mode of action and application of different fungicides, bactericides, nematicides and botanicals; chemotherapy and phytotoxicity of fungicides.

- UNIT V : Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides. New generation fungicides and composite formulations of pesticides, registration and regulation of pesticides
- UNIT VI : Efficacy of different botanicals used and their mode of action. Important botanicals used against diseases. General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

## **Practicals**

Acquaintance with formulation of different fungicides and plant protection appliances. Formulation of fungicides, bactericides, Botanicals and nematicides; Pesticide calculations, *in vitro* evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides against pathogens; persistence, compatibility with other agro-chemicals; detection of naturally occurring fungicide resistant mutants of pathogen; methods of application of chemicals.

# **Suggested Referencess:**

- Bindra O S & Singh H. 1977. *Pesticides And Application Equipment*. Oxford & IBH, New Delhi.
- Nene Y L & Thapliyal P N. 1993. *Fungicides in Plant Disease Control.* 3rd edn. Oxford & IBH, New Delhi.
- Ravichandra, N.G.,2018, Agrochemicals in plant disease management. scientific publishers, Jodhpur, India
- Torgeson D C (Ed.). 1969. *Fungicides*. Vol. II. An Advanced Treatise. Academic Press, New York.

Vyas S C. 1993. Handbook of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

PAT 512	Detection and Management of Seed Borne pathogens	1+1
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- UNIT I : History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.
- UNIT II : Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.
- UNIT III :Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetative propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed- borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.
- UNIT IV :Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogens/ diseases and procedure for healthy seed production. Seed health testing, methods for detecting microorganism.

# **Practicals**

Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses. Relationship between seed-borne infection and expression of the disease in the field.

#### **Suggested Referencess:**

Agarwal VK & JB Sinclair. 1993. Principles of Seed Pathology. Vols. I & II, CBS Publ., New Delhi. Hutchins JD & Reeves JE. (Eds.). 1997. Seed Health Testing: Progress Towards the 21st Century. CABI, Wallington.

Paul Neergaard. 1988. *Seed Pathology*. McMillan, London. Suryanarayana D. 1978. *Seed Pathology*. Vikash Publ., New Delhi.

PAT 513	Biological Control of Plant Diseases	1+1
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#### Theory

- UNIT I : Definitions, importance, history of biological control, Concept of biological control, principles of plant disease management with bioagents, merits and demerits of biological control
- UNIT II Types of biological interactions, operational mechanisms and its relevance in biological control. Competition, competitive saprophytic ability, mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, mycorrhizal associations, antibiosis and induced resistance.
- UNIT III :Factors governing biological control, role of physical environment, agroecosystem and cultural practices in biological control of pathogens. Relationship between pathogens and antagonists, comparative approaches to biological control of plant pathogens by indigenous and introduced antagonists. Biological management of soil-borne and foliar diseases. Compatibility of bioagents with agrochemicals and other antagonistic micobes.
- UNIT IV : Commercial production of antagonists, their delivery systems, application and monitoring, biosafety, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol agents.

### Practicals

Isolation, characterization and maintenance of antagonists, morphological/microscopic observation of major fungal, bacterial and nematode biocontrol agents, methods to study antagonism and antibiosis, application of antagonists against pathogen *in vitro and in vivo* conditions. Preparation of different formulations of selected bioagents and their mass production. Quality parameters of biocontrol agents. Exposure visit to commercial biocontrol agent's production unit.

#### **Suggested Referencess:**

- Campbell R. 1989. *Biological Control of Microbial Plant Pathogens*. Cambridge Univ. Press, Cambridge.
- Cook RJ & Baker KF. 1983. *Nature and Practice of Biological Control of Plant Pathogens*. APS, St. Paul, Minnesota.
- Fokkemma MJ. 1986. Microbiology of the Phyllosphere. Cambridge Univ. Press, Cambridge. Gnanamanickam SS (Eds). 2002. Biological Control of Crop Diseases. CRC Press, Florida.

- Heikki MT & Hokkanen James M (Eds.). 1996. *Biological Control Benefits and Risks*. Cambridge Univ. Press, Cambridge.
- Mukerji K G, Tewari J P, Arora DK & Saxena G. 1992. *Recent Developments in Biocontrol of Plant Diseases*. Aditya Books, New Delhi.

PAT 514	Integrated Disease Management	2+1	
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- UNIT I : Introduction, definition, concept and tools of disease management, components of integrated disease management- their limitations and implications.
- UNIT II : Development of IDM-basic principles, biological, chemical and cultural disease management.
- UNIT III :IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed and mustard, pearl millet, pulses, vegetable crops, fruit, plantation and spice crops.

# Practicals

Application of physical, biological and cultural methods, Use of chemical and biocontrol agents, their compatibility and integration in IDM. Demonstration of IDM and multiple disease management in crops of regional importance as project work.

#### **Suggested Referencess:**

- Gupta V K & Sharma R C. (Eds). 1995. *Integrated Disease Management and Plant Health*. Scientific Publ., Jodhpur.
- Mayee C D, Manoharachary C, Tilak KVBR, Mukadam D S & Deshpande Jayashree (Eds.). 2004. Biotechnological Approaches for the Integrated Management of Crop Diseases. Daya Publ. House, New Delhi.
- Sharma R C & Sharma J N. (Eds). 1995. Integrated Plant Disease Management. Scientific Publ., Jodhpur.

PAT 515	Diseases of Field and Medicinal Crops	2+1
IAI 313	Diseases of Field and Medicinal Crops	<b>4TI</b>

#### Theory

- UNIT I : Diseases of Cereal crops- Rice, wheat, barley, pearl millet, sorghum and maize.
- UNIT II : Diseases of Pulse crops- gram, urd bean, mung bean, lentil, pigeon pea, soybean and cowpea.
- UNIT III :Diseases of Oilseed crops- rapeseed and mustard, sesame, linseed, sunflower, groundnut, castor.
- UNIT IV : Diseases of Cash crops- cotton, sugarcane.
- UNIV V : Diseases of Fodder legume crops- berseem, oats, guar, Lucerne.
- UNIT VI :Medicinal crops- plantago, aromatic grasses (palmarosa, lemongrass, citronella and vetiver), sacred basil, mentha, *ashwagandha*, *Aloe vera*, periwinkle, medicinal coleus, sarpagandha, stevia, geranium, dhavana and sandalwood.

#### Practicals

Detailed study of symptoms and host parasite relationship of important diseases of abovementioned crops. Collection and dry preservation of diseased specimens of important crops.

- Joshi L M, Singh D.V & Srivastava K. D. 1984. *Problems and Progress of Wheat Pathology in South Asia*. Malhotra Publ. House, New Delhi.
- Rangaswami G. 1999. Diseases of Crop Plants in India. 4th Ed. Prentice Hall of India, New Delhi. Ricanel C, Egan BT, Gillaspie Jr AG & Hughes CG. 1989. Diseases of Sugarcane, Major Diseases. Academic Press, New York.
- Singh RS. 2017. Plant Diseases. 10th Ed. Medtech, New Delhi.
- Singh U S, Mukhopadhyay A N, Kumar J & Chaube H S. 1992. *Plant Diseases of International Importance*. Vol. I. *Diseases of Cereals and Pulses*. Prentice Hall, Englewood Cliffs, New Jersey.

PAT 516	Diseases of Fruits, Plantation and Ornamental Crops	2+1
1 AI 310	Diseases of Fruits, Flantation and Ornamental Crops	<i>4</i> ⊤1

#### Theory

- UNIT I :Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm, custard apple and their management.
- UNIT II :Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber, cashew, arecanut and coconut and their management.
- UNIT III :Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, gerbera, orchids, marigold, chrysanthemum, jasmine, crossandra, tuberose and their management.

# Practicals

Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops, fruits and ornamental crops, Collection and dry preservation of diseased specimens of important crops.

#### **Suggested Referencess:**

Gupta V. K. & Sharma S. K. 2000. *Diseases of Fruit Crops*. Kalyani Publ., New Delhi.
Pathak V. N. 1980. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.
Singh R. S. 2000. *Diseases of Fruit Crops*. Oxford & IBH, New Delhi.
Walker J. C. 2004. *Diseases of Vegetable Crops*. TTPP, India.

PAT 517	Diseases of Vegetable and Spices Crops	2+1
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- UNIT I : Nature, prevalence, factors affecting disease development of root, tuber, bulb, leafy vegetable, crucifers, cucurbits, bhendi, leguminaceous and solanaceous vegetables. Diseases of crops under protected cultivation.
- UNIT II : Symptoms etiology, epidemiology and management of diseases of different root, tuber, bulb, leafy vegetables, crucifers, cucurbits, bhendi, leguminaceous and solanaceous vegetable crops.
- UNIT III : Symptoms, etiology, epidemiology and management of diseases of different spice crops such as black pepper, nutmeg, saffron, cumin, coriander, turmeric, fennel, fenugreek, Cardamom, clove, cinnamon, vanilla, Garlic and ginger. Biotechnological approaches in developing disease resistant transgenics.

# Practicals

Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

#### **Suggested Referencess**

Chaube H S, Singh U S, Mukhopadhyay A N & Kumar J. 1992. *Plant Diseases of International Importance*. Vol. II. *Diseases of Vegetable and Oilseed Crops*. Prentice Hall, Englewood Cliffs, New Jersey.

Gupta V K & Paul Y S. 2001. Diseases of Vegetable Crops. Kalyani Publ., New Delhi

- Sherf A F & Mcnab A A. 1986. *Vegetable Diseases and their Control*. Wiley Inter Science, Columbia. Singh RS. 1999. *Diseases of Vegetable Crops*. Oxford & IBH, New Delhi.
- Gupta S K & Thind T S. 2006. *Disease Problem in Vegetable Production*. Scientific Publ., Jodhpur. Walker J C. 1952. *Diseases of Vegetable Crops*. McGraw-Hill, New York.

PAT 518	Post Harvest Diseases	1+1	
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#### Theory

- UNIT I : Concept of post-harvest diseases, definitions, importance with reference to management and health, principles of plant disease management as pre-harvest and post-harvest, Types of post-harvest problems both by biotic and abiotic factors. Mycotoxins, types and effect on human health
- UNIT II : Role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists.
- UNIT III : Study of post-harvest diseases of important fruits and vegetables. Integrated approaches in controlling diseases and improving the shelf life of produce using nutritional, bio-control agents and other agents, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for health hazards
- UNIT IV : Study of symptoms, toxicosis of various pathogens, knowledge of Codex Alimentarius for each product and commodity. Physical and biological agents/practices responsible for development/prevention of post-harvest diseases traditional and improved practices

# Practicals

Isolation, characterization and maintenance of post-harvest pathogens, application of antagonists against pathogens *in vivo* condition. Comparative efficacy of different fungicides and bioagents. Study of different post-harvest disease symptoms on cereals, pulses, oilseed, commercial crops, vegetables, fruits and flowers. Visit to cold storage.

# **Suggested Referencess:**

Pathak VN.1970. Diseases of Fruit Crops and their Control. IBH Publ., New Delhi.

Chaddha K L & Pareek O P.1992. Advances in Horticulture Vol. IV, Malhotra Publ.House, New Delhi.

Paul Neergaard 1977 Seed Pathology, Palgrave Macmillan, Edition I & II.

- UNIT I :Historical development in plant quarantine, Definitions of pest, and transgenics as per Govt. notification; Organizational set up of plant quarantine in India. relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.
- UNIT II : Acts related to registration of pesticides and transgenics. History of quarantine legislations, Salient features of PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.
- UNIT III :Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestation/salvaging of infected material.
- UNIT IV :WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures. Visit to plant quarantine station and PEQ facilities.

## Suggested Referencess:

Rajeev K & Mukherjee R C. 1996. Role of Plant Quarantine in IPM. Aditya Books.

Rhower G G. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental). CRC Press.

#### Theory

- UNIT I: History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Methods of transmission, efficiency of transmission, endosymbionts associated with insect vectors and their role in virus transmission.
- UNIT II: Transmission of plant viruses by fungi, nematodes. Relation between viruses and their vectors.
- UNIT III: Transmission of plant viruses by aphids, whiteflies, mealybugs and thrips.
- UNIT IV: Transmission of phytoplasma and Fastidious vascular bacteria by leaf hoppers and plant hoppers.
- UNIT V: Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

#### Practicals

Identification of common vectors of plant pathogens– aphids, leaf hoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors– aphids, leaf hoppers and whiteflies.

#### **Suggested Referencess**

Basu AN.1995. Bemisiatabaci (Gennadius)–Crop Pest and Principal Whitefly Vector of Plant Viruses. Oxford & IBH, New Delhi.

Harris K F & Maramarosh K. (Eds.).1980. Vectors of Plant Pathogens. Academic Press, London.

- Maramorosch K & Harris KF. (Eds.).1979. Leafhopper Vectors and Plant Disease Agents. Academic Press, London.
- Youdeovei A & Service M W. 1983. Pest and Vector Management in the Tropics. English Language Books Series, Longman, London.

HPP – 521   Wiushroom Production Technology   1+1	HPP – 521	Mushroom Production Technology	1+1
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# Theory

- UNIT I : Historical development of mushroom cultivation and present status, taxonomy, classification, food, medicinal value, uses of mushroom, edible and poisonous mushrooms.
- UNIT II : Biology and life cycle of cultivated mushrooms, reproduction and strain improvement, maintenance of pure culture, preparation of spawn and facilities required for establishing commercial spawn lab.
- UNIT III : Preparation of substrate for mushroom cultivation, long, short and indoor composting methods, formulae for different composts and their computation, qualities and testing of compost, uses of spent mushroom compost *f* substrate.
- UNIT IV : Facilities for setting up mushroom farm for seasonal and environmentally controlled cultivation, requirement and maintenance of temperature, relative humidity, CO2, ventilation in cropping rooms, cultivation technology of Agaricus bisporus, Pleurotus sp., Calocybe indica, Lentinus edodes and Ganoderma lucidum.
- UNIT V : Insect pests, diseases and abnormalities of cultivated mushroom and their management, post harvest processing and value addition, economics of mushroom cultivation, biotechnology and mushroom cultivation.

# Practicals

Preparation of spawn, compost, spawning, casing, harvesting and post-harvest handling of edible mushroom; identification of various pathogens, competitors of various mushroom.

# **Suggested Referencess**

Chadha KL & Sharma SR. 2001. Advances in Horticulture (Mushroom). Vol.

XIII. Malhotra Publ.House, New Delhi.

- Chang ST & Hays WA. 1997. The Biology and Cultivation of Edible Mushrooms, Academic Press, New York.
- Chang ST & Miles PG. 2002. Edible Mushrooms and their Cultivation. CRC Press, Florida.
- Kapur JN. 1989. Mushroom Cultivation. DIPA, ICAR, New Delhi.
- Dhar BL. 2005. Cultivation Technology of High Temperature Tolerant White Button Mushroom. DIPA, ICAR, New Delhi.

Sl.	Course	Course Title	Credit
No.	No.		Hours
Major c	Major courses (Minimum 20 Credits)		
1	MBB 501	Principles of Biotechnology	3+0
2	MBB 502*	Fundamentals of Molecular Biology	3+0
3	MBB 503*	Molecular Cell Biology	3+0
4	MBB 504*	Techniques in Molecular Biology I	0+3
5	MBB 505*	Omics and Systems Biology	2+1
6	MBB 506	Plant Genetic Engineering	3+0
7	MBB 507	Techniques in Molecular Biology II	0+3
8	MBB 508	Introduction to Bioinformatics	2+1
9	MBB 509	Plant Tissue Culture	2+1
10	MBB510	Microbial and Industrial Biotechnology	2+1
11	MBB511	Molecular Plant Breeding	2+1
12	MBB 512	Biosafety, IPR and Bioethics	2+0
13	MBB513	Immunology and Molecular Diagnostics	3+0
14	MBB514	Nano Biotechnology	2+1
15	MBB515	Environmental Biotechnology	3+0
16	MBB516	Bio-entrepreneurship	1+0
17	MBB517	Stress Biology and Genomics	2+0
18	MBB518	Gene Regulation	2+0
19	MBB 519 /	Principles of Genetics	2+1
	GPB 501		
20	MBB 571	Qualifying Examination	0+2
21	MBB 581	Seminar-I	0+1
22	MBB 582	Seminar-II	0+1
23	MBB 591	Research	0+27

# MOLECULAR BIOLOGY AND BIOTECHNOLOGY COURSE STRUCTURE

 23
 MBB 591
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 \* Compulsory among major courses

- Unit I: History, scope and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology *etc.*, Basics of Biotechnology; Primary metabolic pathways, Enzymes and its activities.
- Unit II : Structure of DNA, RNA and protein, their physical and chemical properties. DNA function: expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research, Plant transformation: Gene transfer methods and applications of GM crops.
- Unit III : Molecular analysis of nucleic acids -PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP *etc.*, and their applications; DNA sequencing, different methods; Plant cell and tissue culture techniques and their applications. Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics.
- Unit IV : Introduction to Emerging topics: Genome editing, Gene silencing, Plant microbial interactions, Success stories in Biotechnology, Careers and employment in biotechnology. Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

# **Suggested References**

Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R. 2014. *Molecular Biology of the Gene*, 7th edition, Cold Spring Harbor Laboratory Press, New York

Brown T A. 2010. Gene Cloning and DNA analysis an Introduction 6th edition, Wiley Blackwell
Primrose SB and Twyman R. 2006. Principles of gene Manipulation 7th edition, Wiley Blackwell
Singh BD. 2012. Biotechnology: Expanding Horizons 4th edition, Kalyani publisher, New Delhi, India

MBB 502 Fundamentals of Molecular Biology	3+0
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- Unit I : Historical developments of molecular biology, Nucleic acids as genetic material, Chemistry and nomenclature of nucleic acids; Structure of DNA: primary structure; secondary structure, Forms of DNA: A,B, Z and their function; Structure and types of RNA genome organization in prokaryotes and eukaryotes; DNA topology; DNA reassociation kinetics, Types of repeat sequences.
- Unit II : Central dogma of Molecular Biology; DNA replication- Classical experiments, Models of DNA replication; DNA replication, Origin and Steps in DNA replication initiation, Elongation and termination; Enzymes and accessory proteins and its mechanisms; Eukaryotic DNA replication in brief; Types of DNA damages and mutations; DNA repair mechanisms, Recombination: Homologous and non-homologous, genetic consequences.

- Unit III : Prokaryotic transcription; Initiation, Elongation and Termination; Promoters, Structure and function of eukaryotic RNAs and ribosomal proteins. Eukaryotic transcription- RNA polymerase I, II and III, Elongation and Termination, Eukaryotic promoters and enhancers, Transcription factors, Post transcriptional processing, Splicing: Catalytic RNAs, RNA stability and transport, RNA editing.
- Unit IV : Genetic code and its characteristics, universal and modified genetic code and its characteristics, Wobble hypothesis; Translational machinery; Ribosomes in prokaryotes and eukaryotes. Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes, Elongation: translocation, transpeptidation and termination of translation; Co- and Post-translational modifications of proteins; Translational control; Protein stability -Protein turnover and degradation.
- Unit V : Gene regulation in prokaryotes, Constitutive and inducible expression, Small molecule regulators; Operon concept: *lac* and *trp* operons, attenuation, Anti-termination, Stringent control. Gene regulation in eukaryotes– regulatory RNA and RNA interference mechanisms, Silencers, Insulators, Enhancers mechanism of silencing and activation; Families of DNA binding transcription Helix- factors: turnhelix, helix-loop-helix *etc.* Epigenetic regulations.

- Nelson DL and Cox M.M. 2017. *Lehinger's Principles of Biochemistry*, 7th edition, W H Freeman Publication New York.
- Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. 2017. *Lewin's Genes* XII 12th edition, Jones & Bartlett Learning publisher, Inc.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M and Losick R. 2014. *Molecular Biology of the Gene*, 7th edition, Cold Spring Harbor Laboratory Press, New York.
- Alberts, B. 2017. Molecular Biology of the Cell 5th edition, WW Norton & Co, Inc.
- Allison, L.A. 2011. Fundamentals of Molecular Biology. 2nd Edition, John Wiley and Sons.

<b>MBB 503</b>	Molecular Cell Biology	3+0
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- Unit I : Origin of life, History of cell biology, Evolution of the cell: Endo-symbiotic theory, tree of life, General structure and differences between prokaryotic and eukaryotic cell; Similarities and distinction between plant and animal cells; Different kinds of cells in plant and animal tissues.
- Unit II : Cell wall, cell membrane, structure and composition of bio-membranes, Structure and function of major organelles: Endoplasmic reticulum, Ribosomes, Golgi apparatus, Mitochondria, Chloroplasts, Lysosomes, Nucleus, Peroxisomes, Micro-bodies, Vacuoles, Cytoskeletal elements.
- Unit III : Membrane transport; Diffusion, osmosis, ion channels, active transport, mechanism of protein sorting and regulation of intracellular transport, transmembrane and vesicular transport endocytosis and exocytosis; General principles of cell communication: Hormones and their receptors, Signaling through G-protein coupled receptors, Enzyme linked receptors; Signal transduction mechanisms and regulation, Cell junctions, Cell adhesion, Cell movement; Extracellular matrix.
- Unit IV : Chromatin structure, Cell division and regulation of cell cycle; Mechanisms of cell division, Molecular events at M phase, mitosis and cytokinesis, Ribosomes in relation

to cell growth and division, Extracellular and intracellular control of Cell Division; Abnormal cell division: cancer- hall marks of cancer and role of oncogenes and tumor suppressor genes in cancer development - Programmed cell death (Apoptosis).

Unit V : Morphogenetic movements and the shaping of the body plan, cell diversification, cell memory, cell determination, and the concept of positional values; Differentiated cells and the maintenance of tissues and organ development; Stem cells: types and applications; Basics of Animal development in model organisms (*C. elegans*; *Drosophila*); Plant development.

# Suggested References

Alberts, B. 2017. Molecular Biology of the Cell 5th edition, WW Norton & Co, Inc.

- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin, K.C., 2016. *Molecular Cell Biology* 8<sup>th</sup> Edition. W.H. Freeman & Co. New York.
- Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Hopkin, K., Johnson, A., Walter, P.,

2013 Essential of Cell Biology, WW Norton & Co, Inc.

Cooper, G.M. and Hausman, R.E. 2013. *The cell: A Molecular Approach* 6<sup>th</sup> edition, Sinauer Associates, Inc.

MBB 504	Techniques in Molecular Biology I	0+3

# Practicals

- Good lab practices, preparation of buffers and reagents.
- Principle of centrifugation and spectrophotometry.
- Growth of bacterial culture and preparation of growth curve, Isolation of Genomic DNA from bacteria.
- Isolation of plasmid DNA from bacteria.
- Growth of lambda phage and isolation of phage DNA.
- Isolation and restriction of plant DNA (e.g. tomato / Moong / Mango / Merigold).
- Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry
- PCR using isolated DNA.
- PAGE Gel electrophoresis.
- Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNA construction.
- Transformation of E. coli and selection of transformants
- Chromatographic techniques

a. TLC

- b. Gel Filtration Chromatography,
- c. Ion exchange Chromatography,
- d. Affinity Chromatography
- Dot blot analysis, Southern hybridization, Northern hybridization.
- Western blotting and ELISA.
- Radiation safety and non-radio isotopic procedure.

## **Suggested References**

Sambrook, J., and Russell, R.W. 2001. *Molecular Cloning: A Laboratory Manual* 3rd Edition, Cold spring harbor laboratory press, New York.

Wilson, K., and Walker, J., 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8<sup>th</sup> edition, Cambridge University Press.

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA and Struhl K. 2002. *Short Protocols in Molecular Biology* 5<sup>th</sup> edition, Current Protocols publication.

- Unit I : Different methods of genome sequencing, Principles of various sequencing chemistries, physical and genetic maps, Comparative and evolutionary genomics, Organelle genomics, Applications in phylogenetics, Case studies of completed genomes, Preliminary genome data analysis, basics of ionomics analysis, different methods.
- Unit II : Protein-basics: Primary-, secondary- and tertiary structure, Basics of X-ray crystallography and NMR, Principle and Applications of mass spectrometry, Proteomics: Gel based and gel free; Basics of software used in proteomics, MASCOT, PD-Quest, *etc.*, Study of protein interactions, Prokaryotic and yeast-based expression system and purification.
- Unit III : Metabolomics and its applications, Use of 1D/2D NMR and MS in metabolome analysis, Multivariate analysis and identification of metabolite as biomarkers, Study of ionome using inductively coupled plasma – Mass spectroscopy (ICP-MS), X-Ray Fluorescence (XRF), Neutron activation analysis (NAA), Data integration using Genome, Transcriptome, Proteome, Metabolome and Ionome with Phenome.
- Unit IV : Introductory systems Biology The biochemical models, genetic models and systems model, Molecules to Pathway, Equilibrium binding and cooperatively Michaelis- Menten Kinetics, Biological oscillators, Genetic oscillators, Quorum Sensing, Cell- cell communication, *Drosophila* Development, Pathways to Network, Gene regulation at a single cell level, transcription network, Regulatory Circuits, Negative and positive auto-regulation, Alternative Stable States, Bimodal Switches, Network building and analysis.

#### **Practicals**

- Isolation of HMW DNA and brief overview of sequencing, Primary information on genome data analysis.
- BSA Standard curve preparation, Extraction of protein and estimation methods.
- Quantification of proteins from different plant tissues using spectrophotometry.
- 2-D Gel Electrophoresis, 2-D Image analysis.
- Experiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitin system).
- Demonstration on MALDI-TOF.
- Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods.

# **Suggested References**

- Primrose, S.B. and Twyman, R. 2006. Principles of Gene Manipulation 7th edition, Wiley Blackwell
- Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th Edition, Cambridge University Press.

- Unit I : Historical background, Restriction Enzymes; DNA Modifying enzymes, Ligase, T4 DNA polymerase, Polynucleotide kinase *etc.*, Cohesive and blunt end ligation; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence *in situ* hybridization; Chromatin Immuno precipitation; DNA-Protein Interactions: Electromobility shift assay.
- Unit II: Plasmids; Bacteriophages; M13, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; Expression vectors; pMal, pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag, *etc.*; Baculovirus vectors system, Plant based vectors, Ti and Ri plasmids as vectors, Yeast vectors, Shuttle vectors. Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning, Jumping and hopping libraries, Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression; Codon optimization for heterologous expression. Introduction of DNA into mammalian cells; Transfection techniques.
- Unit III : Principles of PCR, Primer design, DNA polymerases, Types of PCR multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T- vectors; Applications of PCR in gene recombination, Site specific mutagenesis, in molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay.
- Unit IV : Genetic transformation of plants: DNA delivery Agrobacterium mediated method. Direct DNA delivery chemical mediated electroporation and particle bombardment. Vectors and transgene design Promoters and Marker genes. Chloroplast transformation. Development of marker-free plants. Analysis of transgenic plants-Molecular and Biochemical assays, genetic analysis Identification of gene integration site Advance methods *cis* genesis, intragenesis and targeted genome modification ZFN, TALENS and CRISPR. Application of transgenic technology.

#### **Suggested References**

- Brown, T.A. 2010. Gene Cloning and DNA Analysis an Introduction. 6th edition, Wiley Blackwel.
- Primrose, S.B. and Twyman, R. 2006. *Principles of Gene Manipulation* 7th edition, Wiley Blackwell.
- Sambrook, J., and Russell, R.W. 2001. *Molecular cloning: A laboratory manual* 3rd Edition, Cold spring harbor laboratory press, New York.
- Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th Edition, Cambridge University Press.

#### **Techniques in Molecular Biology II MBB 507**

### **Practicals**

- Construction of gene libraries (cDNA and Genomics).
- Synthesis and cloning of cDNA.
- Real time PCR and interpretation of data.
- Molecular markers
  - i. RAPD.
  - ii. SSR.
  - iii. AFLP / ISSR and their analysis.
- Case study of SSR markers construction of linkage map.
- QTL analysis using genotypic data based on SSR.
- SNP identification and analysis.
- Microarray studies and use of relevant software.
- Proteomics
  - i. 2D gels,

ii.Mass spectrometry

- RNAi designing of construct, phenotyping of the plant.
- Yeast 1 and 2-hybrid interaction.
- Generation and screening of mutants.
- Transposon mediated mutagenesis.
- Immunology and molecular diagnostics: Ouchterlony double diffusion, Immunoprecipitation, Radiation Immunodiffusion, Immunoelectrophoretic, Rocket Immunoelectrophoretic, Counter Current Immunoelectrophoretic, ELISA, Latex Agglutination, Immunohistochemistry.

#### **Suggested References**

- Wilson, K., and Walker, J. 2018. Principles and Techniques of Biochemistry and Molecular **Biology 8th Edition, Cambridge University Press**
- Bonifacino, J. S., Dasso, M., Harford, J. B., Liipincott-Schwartz, J., and Yamada, K. M. 2004. ShortProtocols in Cell Biology. John Wiley & Sons, New Jersey
- Hawes, C., and Satiat-Jeunemaitre, B. 2001. Plant Cell Biology: PracticalsApproach. Oxford University Press, Oxford
- Sawhney, S.K., Singh, R. 2014. Introductory PracticalsBiochemistry, Alpha science international limit.

- Unit I: Bioinformatics basics, scope and importance of bioinformatics; Biological databases for DNA and Protein sequences -PIR, SWISSPROT, GenBank, DDBJ, secondary database, structural databases -PDB, SCOP and CATH, Specialized genomic resources, Microarray database.
- Unit II: Bioinformatics Tools Facilitate the Genome-Wide Identification of Protein-Coding Genes, Sequence analysis, Sequence submission and retrieval system-SEQUIN, BANKit, SAKURA, Webin, Sequence alignment, Pair wise alignment techniques,

multiple sequence alignment; Tools for Sequence alignment- BLAST and its variants; Phylogenetic analysis- CLUSTAL X, CLUSTAL W, Phylip, Tcoffee.

Unit III : Sequencing of protein; Protein secondary structure prediction- Chousfasman, GOR Method, Protein 3D Structure Prediction: Evaluation of models- Structure validation and refinement - Ramachandran plot, Force field calculations, SAVES. Protein function prediction- Sequence and domain based, Primer designing- principles and methods. Drug discovery, Structure Based Drug Design- Rationale for computer aided drug designing, basic principles, docking, QSAR.

# Practicals

- Usage of NCBI resources
- Retrieval of sequence/structure from databases and submission
- Different Databases, BLAST exercises.
- Assembly of DNA and RNA Seq data
- Annotation of assembled sequences, Phylogenetics and alignment
- Visualization of structures, Docking of ligand receptors
- Protein structure analysis and modeling.

# **Suggested References**

- Attwood, T.K., and Parry-Smith, D. J. 2004. *Introduction to Bioinformatics*, Pearson Education (Singapore) Pvt. Ltd.
- David Edwards (Ed.) 2007. *Plant Bioinformatics: Methods and Protocols*. Humana Press, New Jersey, USA.

Cold Spring Harbor Laboratory Press, U.S.

Pevsner J. 2009. Bioinformatics and Functional Genomics, 2nd edition, Wiley-Blackwell.

MBB 509	Plant Tissue Culture	2+1
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- Unit I (12 Lectures) : History of plant tissue culture, Principle of Totipotency; Tissue culture media; Plant hormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of plant tissue culture; National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods – PCR, ELISA
- Unit II (12 Lectures) : Micropropagation of field and ornamental crops; Virus elimination by meristem culture, meristem tip culture and micrografting; Androgenesis and gynogenesis production of androgenic and gynogenic haploids diploidization; Protoplast culture isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybridization Production of Somatic hybrids and Cybrids; Wide hybridization embryo culture and embryo rescue techniques; Ovule, ovary culture and endosperm culture.
- Unit III (12 Lectures) : Large-scale cell suspension culture Production of alkaloids and other secondary metabolites- techniques to enhance secondary metabolite production, Somaclonal and gametoclonal variations causes and applications; Callus culture and *in vitro* screening for stress tolerance; Artificial seeds, *In vitro* germplasm storage and cryo-preservation. Commercial Tissue Culture: Case studies and success stories, Market assessment; Project planning and preparation, economics, government policies.

# Practicals (12)

- Preparation of stocks macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium.
- Micro-propagation of plants by nodal and shoot tip culture.
- Embryo culture to overcome incompatibility, Anther culture for haploid production.
- Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis.
- Acclimatization of tissue culture plants and establishment in greenhouse.
- Virus indexing in tissue culture plants (Using PCR and ELISA).
- Plan of a commercial tissue culture unit.

# **Suggested References**

Razdan, M.K. 2003. *Introduction to plant tissue culture*, 2nd edition, Oxford publications group Butenko, R.G. 2000. *Plant Cell Culture* University Press of Pacific

Herman, E.B. 2008. *Media and Techniques for Growth, Regeneration and Storage*, Agritech Publications, New York, USA.

- Bhojwani, S.S and Dantu P. 2013. *Plant Tissue Culture An Introductory Text*. Springer Publications.
- Gamborg, O.L and G.C. Philips (eds.). 2013. *Plant Cell, Tissue and Organ culture-Lab Manual*. Springer Science & Business media.

	MBB 510	Microbial and Industrial Biotechnology	2+1
Theory			

- Unit (8 Lectures) : Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms.
- Unit II (8 Lectures) : Primary metabolites, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non-ribosomal peptide antibiotics as case study; Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry.
- Unit III (8 Lectures) : Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio-transformations, Bio- augmentation with production of vitamin C as a case study; Bioreactors, their design and types; Immobilized enzymes-based bioreactors; Microencapsulation technologies for immobilization of microbial enzymes.
- Unit IV (8 Lectures) : Environmental Biotechnology, biotreatment for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bio- remediation of soil; Production of eco-friendly agricultural chemicals, bio- pesticides, bio-herbicides, bio-fertilizers, bio-fuels, *etc*.

- Isolation of industrially important microorganisms, their maintenance and improvement.
- Lab scale production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery.

- Study of bio-reactors and their operations.
- Production of bio-fertilizers.
- Experiments on microbial fermentation process of antibiotics, bio-pigments, dairy products, harvesting purification and recovery of end products.
- Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomassestimation.
- Determination of mass transfer coefficient.

- Waites, M.J., Morgan, N.L., Rockey, J.S., Higton, G. 2001. *Industrial Microbiology: An Introduction*, Wiley-Blackwell.
- Slater, A., Scott, N.W., & Fowler, M.R. 2003. *The Genetic Manipulation of Plants. Plant Biotechnology Oxford, England: Oxford University Press.*
- Kun, L.Y. (Ed.). 2003. *Microbial biotechnology: principles and applications*. World Scientific Publishing Company.

# MBB 511 Molecular Plant Breeding

# Theory

- Unit I (8 Lectures) : Inheritance of qualitative and quantitative traits. Heritability its estimation, Population structure of self- and cross-pollinated species, Factors affecting selection efficiency; Development of different kinds of segregating populations F<sub>2</sub>, F<sub>3</sub>, BC<sub>1</sub>F<sub>1</sub>, BC<sub>1</sub>F<sub>2</sub>, BC<sub>4</sub>F<sub>2</sub>, RIL (Recombinant Inbred Lines), AIL (Advanced Intercrossed Lines), DH (Di-haploid population), NIL (Near Isogenic lines), NAM (Nested Association Mapping), MAGIC (Multi-parent Advanced Generation Intercross population).
- Unit II (8 Lectures) : Causes of sequence variation and its types, Types of molecular markers and development of sequence based molecular markers – RFLP, AFLP, SCARs, CAPS, SSRs, STMS, SNPsInDel and DARTseq; Inheritance of markers, Linkage analysis using test cross, F<sub>2</sub>, F<sub>3</sub>, BC<sub>1</sub>F<sub>1</sub>, RIL. Construction of genetic map, Mapping genes for qualitative traits; Genotyping by sequencing and high-density chip arrays.
- Unit III (8 Lectures): QTL mapping using structured populations; Association mapping using unstructured populations; Genome Wide Association Studies (GWAS), Principle of Association mapping– GWAS-SNP genotyping methods, DART array sequencing, Illumina's Golden Gate Technology, Genotyping by sequencing methods- Fluidigm; GBS, Illumina Hi seq- Nano pore sequencing, Principles and methods of Genomic Selection, Fine mapping of genes/QTL; Development of gene based markers; Allele mining by TILLING and Eco-TILLING.
- Unit IV (8 Lectures) : Tagging and mapping of genes. Bulk segregant and co-segregation analysis, Marker assisted selection (MAS); Linked, unlinked, recombinant, flanking, peak markers. Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples. Haplotype concept and Haplotype-based breeding; Genetic variability and DNA fingerprinting. Molecular markers in Plant variety protection, IPR issues, hybrid purity testing, clonal fidelity testing and transgenic testing.

2 - + 1
## **Practicals**

- Construction of linkage map.
- QTL analysis using the QTL cartographer and other software.
- SNP data analysis using TASSEL.
- Detection of haplotype block using SNP data pLinksoftware.
- Genotyping by sequencing methods –Illumina genotyping platform.
- Marker assisted breeding MABB case studies quality traits in rice/maize.
- Genome Assisted Breeding in model crops, Genomic Selection models using the morphological and SNP data

## **Suggested References**

Acquaah, G. 2007. Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd. USA.

- Weising, K., Nybom, H., Wolff, K., and Kahl, G. 2005. *DNA Fingerprinting in Plants: Principles, Methods and Applications*, 2nd ed. Taylor and Francis Group, Boca Raton, FL.
- Halford, N. 2006. *Plant Biotechnology-Current and future applications of genetically modified crops*, John Wiley and Sons, England.
- Singh, B. D. and Singh, A. K. 2015. *Marker-Assisted Plant Breeding: Principles and Practices* Springer (India) Pvt. Ltd.
- Boopathi, NM. 2013. *Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits*. Springer India. p293.

MBB 512	Bio Safety, IPR & Bioethics	2+0
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#### Theory

- Unit I (10 Lectures) : IPR: historical background in India; trade secret; patent, trademark, design& licensing; procedure for patent application in India; Patent Cooperation Treaty (PCT); Examples of patents in biotechnology-Case studies in India and abroad; copyright and PVP; Implications of IPR on the commercialization of biotechnology products, ecological implications; Trade agreements- The WTO and other international agreements, and Cross border movement of germplasms.
- Unit II (8 Lectures) : Biosafety and bio-hazards; General principles for the laboratory and environmental bio-safety; Biosafety and risk assessment issues; Handling and disposal of bio- hazards; Approved regulatory laboratory practice and principles; The Cartagena Protocol on biosafety; Biosafety regulations in India; National Biosafety Policy and Law; Regulations and Guidelines related to Biosafety in other countries.
- Unit III (8 Lectures) : Potential concerns of transgenic plants Environmental safety and food and feed safety. Principles of safety assessment of Transgenic plants – sequential steps in risk assessment. Concepts of familiarity and substantial equivalence. Risk -Environmental risk assessment – invasiveness, weediness, gene flow, horizontal gene transfer, impact on non-target organisms; food and feed safety assessment –toxicity and allergenicity. Monitoring strategies and methods for detecting transgenics.
- Unit IV (6 Lectures) : Field trails Biosafety research trials standard operating procedures, labeling of GM food and crop, Bio-ethics- Mankind and religion, social, spiritual & environmental ethics; Ethics in Biotechnology, labeling of GM food and crop; Biopiracy.

#### **Suggested References**

Goel, D. and Parashar, S. 2013. IPR, biosafety, and bioethics.
Joshi, R. 2006. Biosafety and Bioethics.
Nambisan, P. 2017. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology.

MBB 513	Immunology and Molecular Diagnostics	3+0
Theory		

- Unit I (6 Lectures) : Immunity and its classification; Components of innate and acquired immunity; Lymphatic system; Hematopoiesis; Organs and cells of the immune systemprimary, secondary and tertiary lymphoid organs Descriptions of Antigens - immunogens, hapten and adjuvants.
- Unit II (12 Lectures) : Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Basis of self and non- selfdiscrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell- mediated immune responses, ADCC; Cluster of Differentiations (CDs), Cytokines- properties, receptors and therapeutic uses.
- Unit III (8 Lectures) : Phagocytosis; Complement and Inflammatory responses; Major Histocompatibility Complex MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing; Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten-carrier system Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosenor assays for assessing ligand –receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, Transgenic mice, Gene knock outs.
- Unit V (12 Lectures) : Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies, Immunity to Infection; Ba cteria, viral, fungal and parasitic infections, Hypersensitivity Type I-IV; Autoimmunity; Types of autoimmune diseases, MHC and TCR in autoimmunity; Transplantation, Immunological basis of graft rejection, immunosuppressive therapy; Tumor immunology Tumor antigens.

#### **Suggested References**

- Owen J.A., Punt, J., & Stranford, S. A. 2013. *Kuby immunology* (p. 692). New York: WH Freeman.
- Kenneth, M., and Weaver, C. 2017. *Janeways Immunobiology*, 9<sup>th</sup> Edition, New York, USA: Garland Science, Taylor & Francis publisher.
- William, P. 2013. *Fundamental of Immunology*, 7<sup>th</sup> edition, Lippencott, William and Wilkins publisher.

- Unit I (8 Lectures) : Introduction to Nanotechnology Nanomaterials Self-assembly to artificial assembly for creation of useful nanostructures Bottoms up and Top down approach (Nano rods, nano cages, nanotubes, quantum dots, nanowires, metal/ polymer-based nanostructures) Preparation and Characterization of nanoparticles (particle size analyzer, microscopy, *viz.* electron microscopy, atomic force microscopy, *etc.*).
- Unit II (8 Lectures) : Cell structure Bio macromolecules: Types, Structure, Dynamics and interaction with water Cellular nano machines cellular transducers, membrane channels, membrane transporters, Membrane motors Creation of bio-nanostructures (Nano liposomes, Nano micelles, Nanomotors, *etc.*).
- Unit III (8 Lectures) : Chemical, physical and biological properties of biomaterials and bio response: biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems,
- Unit (8 Lectures) : Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

## Practicals

- Isolation of enzymes and nucleic acids involved in biosynthesis of nanomaterials
- Synthesis of Gold/silver Nanoparticles by biogenic methods, Synthesis of micelles and inverse micelles
- Synthesis of Carbon Nano-materials by Chemical Vapor Deposition and Sputtering technique
- Preparation ofthiolate silver nanoparticles, Purification and measurement of carbon nano materials
- Zinc selenide quantum dot preparation, Synthesis of Iron Oxide Nanoparticle
- Thin film preparation by spin coating technique, Synthesis of Nickel metal nanoparticle by urea decomposition method
- Synthesis of Zinc Oxide nanoparticle

## Suggested References

Nalwa, H.S. 2005. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology. American Scientific Publications.

- Niemeyer C.M. and Mirkin C.A. (Eds) 2005. *Nanobiotechnology: Concepts Applications and Perspectives*, Wiley Inter-science publications.
- Cao, G., and Wang, Y. 2004. *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, Imperial College Press.

- Unit I (8 Lectures) : Basic concepts and environmental issues; types of environmental pollution; Problems arising from high-input agriculture; Methodology of environmental management; Air and water pollution and its control; Waste water treatment physical, chemical and biological processes; Need for water and natural resource management.
- Unit II (8 Lectures) : Microbiology and use of micro-organisms in waste treatment; Biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides and toxic chemicals, detergents *etc*; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, *etc.*); anaerobic processes: digestion, filtration, *etc*. Renewable and non-Renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas; microbial hydrogen production; conversion of sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture *etc*.
- Unit IV (8 Lectures) : Treatment schemes of domestic waste and industrial effluents; Food, feed and energy from solid waste; Bioleaching; Enrichment of ores by microorganisms; Global environmental problems: Ozone depletion, UV-B, Greenhouse effects, and Acid rain; Biodiversity and its conservation; Biotechnological approaches for the management environmental problems.

#### **Suggested References**

- Evans, G. M. and Furlong, J. C. 2010. *Environmental Biotechnology: Theory and Application*. 2nd edition, Wiley-Blackwell.
- Jordening HJ and Winter J. 2006. Environmental Biotechnology: Concepts and Applications. Wiley-VCH Verlag.

1	MBB 516	Bio-entrepreneurship	1+0
		Die entrepreneursmp	1.0

#### Theory

- Unit I (4 Lectures) : Scope in biotechnology; types of bio-industries bio-pharma, bio-agri, bioservices and bio-industrial; Importance of entrepreneurship; Introduction to bioentrepreneurship – Biotechnology in a global scale; –Skills for successful entrepreneur– creativity, leadership, managerial, team building, decision making; Opportunities for bioentrepreneurship, entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India)
- Unit II (4 Lectures) : Business plan preparation; Business feasibility analysis by SWOT, Socioeconomic costs benefit analysis; Funds/ support from various agencies; Statutory and legal requirements for starting a company/ venture.
- Unit III (4 Lectures) : Entry and exit strategy; Identifying needs of customers; Market linkages, branding issues; Developing distribution channels franchising; Policies, promotion, advertising; Branding and market linkages for 'virtual startup company'. Pricing strategy.

Unit IV (4 Lectures) : Knowledge centers *e.g.*, in universities, innovation centres, research institutions (public & private) and business incubators; R&D for technology development and upgradation; Assessment of technology development; Managing technology transfer.

#### **Suggested References**

- Adams, D.J. and Sparrow, J.C. 2008. *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences*. Bloxham: Scion.
- Shimasaki, C.D. 2014. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
- Onetti, A., and Zucchella, A. 2014. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
- Jordan, J. F. 2014. Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
- Desai, V. 2009. *The Dynamics of Entrepreneurial Development and Management*. New Delhi: Himalaya Pub. House.

MBB 517 Stress Biology and Genomics	2+0
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#### Theory

- Unit I (10 Lectures) : Different kinds of stresses (biotic and abiotic) and adaptation strategies: Plant cell as a sensor of environmental changes; Role of cell membranes in signal perception; Ways of signal transduction in cells and whole plants as a response to external factors. Abiotic stresses affecting plant productivity Drought, salinity, water logging, temperature stresses, light stress and nutrient stress; Drought stress Effects on plant growth and development; Components of drought resistance; Physiological, biochemical and molecular basis of tolerance mechanisms; Biotic stress (insect and pathogen) resistance mechanism.
- Strategies to manipulate drought tolerance Osmotic adjustment and Unit II (12 Lectures) : Osmoprotectants - synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants; Hormonal metabolism - ABA signaling; signaling components-transcription factors. Water logging stress – effects on plant growth and metabolism; adaptation to water logging, tolerance mechanisms -hormones and flooding tolerance. Strategies for improving submergence tolerance. Salinity stress effects on physiology and metabolism of plants, SOS pathways and ion homeostasis, Strategies to improve salinity tolerance in plants. Water logging stress-effects on plant growth and metabolism; tolerance mechanisms. Physiological and biochemical changes - High & Low temperature tolerance mechanisms - molecular basis of thermo tolerance. Morphological and physiological changes in plants due to high and low light stresses - photo oxidation -plastid development. Characters of heliophytes and sciophytes - solar tracking - sieve effect and light channeling. Heavy metal stress - Al and Cd stress effects on plant growth and development, Biotech strategies to overcome heavy metal stress Nutrient stress- effects on plant growth and development. Genetic manipulation strategies to overcome the stress effects. Genomics; transcriptomes, small RNAs and epigenomes; functional genomics; transfer of tolerance/resistant genes to model plants and validation of gene function. Different techniques for the functional validation of genes. Signaling pathway related to defense gene expression, R proteins, RNAi approach and genes from pathogens and other sources, coat protein genes, detoxification genes, transgenic and disease management. Bt proteins, resistance management strategies in transgenic crops, ecological impact of field

release of transgenic crops. Bioinformatics approaches to determine gene function and network in model plants under stress.

#### **Suggested References**

- Buchanan, B.B., Gruissem, W. and Jones R. 2015. *Biochemistry and Molecular Biology of Plants*, 2nd edition, Wiley and Blackwell Publications.
- Sarwat, M., Ahmad, A., Abdin, M.Z. 2013. *Stress Signaling in Plants: Genomics and Proteomics Perspective*, Volume 1, Springer.

Heribert Hirt. 2010. *Plant Stress Biology: From Genomics to Systems Biology*, John Wiley. Pandey, G.K. 2015. *Elucidation of Abiotic Stress Signaling in Plants*, Stringer.

MDD = 10		2.0
MBB 218	Gene Regulation	2+0

## Theory

- Unit I (8 Lectures) : Transcriptional regulation Regulatory proteins, Activators and Repressors, Binding of RNA polymerase, Allosteric regulation, DNA looping, Cooperative binding, Antitermination, Combinatorial control – Regulation of *lac, trp* and *ara* Operons. Gene regulation in Lambda phage – lytic or lysogenic establishment.
- Unit II (10 Lectures) : Regulatory sequences Promoters, Enhancers, Silencers, Insulators, Locus Control Region. Activator proteins and their binding sites, DNA binding domain Homeodomain, Zinc containing proteins, Leucine Zipper Motif, Helix-Loop-Helix, HMG proteins. Recruitment of RNA polymerase to promoter region, Nucleosomes and their modifiers. Signal integration. Signal transduction and transcriptional regulation. Gene Silencing. Epigenetic gene regulation.
- Unit III (10 Lectures) : Regulation by RNA in prokaryotes and eukaryotes, RNA as defense agents.
   Ribo- switches. Gene Silencing by RNA siRNA & miRNA synthesis and function. Non-coding RNAs their impact, categories and role in gene regulation; Chromatin assembly *etc*. Negative auto-regulation, Positive auto-regulation, Bistable and Bimodal switch, Oscillating pattern of gene expression.

#### **Suggested References**

- Nelson, D. L. and Cox, M. M. 2017. *Lehinger's Principles of Biochemistry*, 7th edition, W H Freeman Publication New York
- Krebs, J. E., Goldstein, E. S., Kilpatrick, S. T. 2017. *Lewin's Genes* XII 12th edition, Jones & Bartlett Learning publisher, Inc
- Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Lonick, R. 2014. *Molecular Biology of the Gene*, 7th Edition, Cold Spring Harbor Laboratory Press, New York.
- Gardner, E. J., Simmons MJ and Snustad, D.P. 2006. Principles of Genetics (2006) eighth Edition. Wiley

- 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, polygenic inheritance, Meiotic drive, Somatic cell genetics, Haploid Genetics and Genetics of DNA markers, Extra chromosomal inheritance, Genome imprinting.
- 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;Basics, Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression, RNA editing.
- Unit IV : Basics of 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; Transgenic bacteria and bioethics; Gene silencing; Genetics of mitochondria and chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders.

## Practicals

- 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;
- Use of Agrobacterium mediated method and Biolistic gun;
- Visit to transgenic glasshouse and learning the Practicalsconsiderations.

#### Suggested References

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. 8<sup>th</sup> 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 Benzamin/ 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. 6<sup>th</sup> 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<sup>th</sup> edition.
- Uppal S, Yadav R, Singh S and Saharan RP. 2005. *PracticalsManual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

Sl. No.	Course No.	Course Title	Credit Hours
Major c	ourses (Minim	um 20 Credits)	
1	SAC 501	Analytical Techniques in Soil and Plant Analysis	1+1
2	SAC 502*	Soil Mineralogy, Genesis, Survey and Classification	2+1
3	SAC 503*	Soil Physics	2+1
4	SAC 504*	Soil Chemistry	2+1
5	SAC 505	Soil Biology and Soil Biochemistry	1+1
6	SAC 506*	Soil Fertility and Nutrient Management	2+1
7	SAC 507	Management of Problematic Soils and Waters	1+1
8	SAC 508	Soil, Water and Air Pollution	1+1
9	SAC 509	Soil Testing & Fertilizer Recommendation	1+1
10	SAC 510	Manures & Fertilizers	1+1
11	SAC 511	Agricultural Chemicals	1+1
12	SAC 512	Soil Erosion and Conservation	1+1
13	SAC 571	Qualifying Examination	0+2
14	SAC 581	Seminar-I	0+1
15	SAC 582	Seminar-II	0+1
16	SAC 591	Research	0+27

# **SOIL SCIENCE**

\* Compulsory among major courses

SAC 501	Analytical Techniques in Soil and Plant Analysis	1+1

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation-reduction and complexo-metric titration; electrochemical titration of clays. Nutrient potentials and potential buffering capacities

and fixation capacity of soils for phosphorus, ammonium and potassium; estimation of phosphorus, ammonium and potassium. Principles of visible, ultraviolet and infrared spectrophotometery, atomic absorption spectroscopy, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry. Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods.

## Practicals

Principles of analytical chemistry, Sampling of soils, water, effluents and plant, Estimation of electrochemical properties of soils, Estimation of cation and anion exchange capacity of soils, Chemical analyses of soils and interpretation and recommendation, Chemical analyses of plant and interpretation and recommendation.

## **Suggested References**

Saha, A.K., Methods of physical and chemical analysis of soil
Chopra, S.L., and Kanwar, J.S., Analytical Agricultural Chemistry
A.K. Gupta., PracticalsManual for Agricultural Chemistry
ISSS, New Delhi., Fundamentals of Soil Science
Chatwal and Anand., Instrumental Methods of Chemical Analysis
Dhyan Singh et al., Manual on soil, plant and water analysisNyle C.Brady and Ray R. Weil., Nature and properties of soils

SAC 502	Soil Mineralogy, Genesis, Survey and Classification	2+1

## Theory

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism. Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils. Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils. Concept of soil individual; soil classification systems - modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps - usefulness. Soil survey and its types; soil survey techniques - conventional and modern; soil series - characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps. Landform - soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT) - concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

# Practicals

Identification and quantification of minerals in soil fractions by X- ray and different methods. Morphological properties of soil profile in different landforms, Classification of soils using soil taxonomy, Calculation of weathering indices and its application in soil formation, Grouping soils using available data base in terms of soil quality, Aerial photo and satellite data interpretation for soil and land use, Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and construction of maps in different scales, Land use planning exercises using conventional and RS tools

# **Suggested References**

Sehgal, J., A Text Book of Pedology
Saha, A.K., Methods of physical and chemical analysis of soil
ISSS, New Delhi., Fundamentals of Soil Science
PC Das., Soils in India
Dipak Sarkar and Abhijit Haldar., Fundamental Principles of Soil Science
Nyle C. Brady and Ray R. Weil., Nature and propertices of Soils

SAC 505 Boll Litysics 211
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# 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. Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soiltemperature management.

## Practicals

• 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 soilwater content by different methods, 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.

# **Suggested References**

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.

## SAC 504 Soil Chemistry

## Theory

- Unit I : Chemical (elemental) composition of the earth's crust, soils, rocks and minerals
- Unit II :Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.
- Unit III :Soil colloids: inorganic and organic colloids origin of charge, concept of point of zerocharge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions.
- Unit IV : Ion exchange processes in soil; cation exchange- theories based on law of massaction (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorptionisotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionicactivity measurement, thermodynamics, statistical mechanics; anion and ligand exchange– Restructured and Revised Syllabi of Post-graduate Programmes Vol. 2 innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresisin sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC,

2+1

CEC; experimental methods to study ion exchange phenomena and Practicalsimplications in plant nutrition.

- Unit V : Potassium, phosphate and ammonium fixation in soils covering specificand nonspecific sorption; precipitation-dissolution equilibria; Conceptof quantity/intensity(Q/ I)relationship; step and constant-rate K; managementaspects.
- Unit VI :Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.
- Unit VII :Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.
- Unit VIII : Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry

## Practicals

Preparation of saturation extract, measurement of pH, EC, CO, HCO, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Extraction of humic substances, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the D (E4/E6) values at two pH values, Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by BaCl2-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

#### **Suggested References**

Bear RE. 1964. Chemistry of the Soil. Oxford and IBH.
Bolt GH and Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.
Greenland DJ and Hayes MHB. 1981. Chemistry of Soil Processes. John Wiley & Sons.
Greenland DJ and Hayes MHB. Chemistry of Soil Constituents. John Wiley & Sons.
McBride MB. 1994. Environmental Chemistry of Soils. Oxford University Press.
Sposito G. 1981. The Thermodynamics of Soil Solutions. Oxford University Press.
Sposito G. 1984. The Surface Chemistry of Soils. Oxford University Press.
Sposito G. 1989. The Chemistry of Soils. Oxford University Press.
Stevenson FJ. 1994. Humus Chemistry. 2nd Ed. John Wiley & Sons.
Van Olphan H. 1977. Introduction to Clay Colloid Chemistry. John Wiley & Sons.

## Theory

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota. Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora. Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures;

biotic factors in soil development; microbial toxins in the soil. Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost. Biofertilizers – definition, classification, specifications, method of production and role in crop production.

#### Practicals

Determination of soil microbial population, Soil microbial biomass, Elemental composition, fractionation of organic matter and functional groups, Decomposition of organic matter 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

## **Suggested References**

- Buscot, F and Ajit Verma., Micro organisms in soils: Roles in Genesis and Formation ISSS, New Delhi., Fundamentals of Soil Science
- Page et al (Ed) SSSA Book Series, UAS., Methods of Soil Analysis Part 2: Chemical and microbiological propertices
- Sadashivam, S and Manickam, A ., Biochemical methods

Bollag, J.M., and Stotzky., Soil Biochemistry

Nyle C. Brady and Ray R Weil., Nature and propertices of soils

SAC 506Soil Fertility and Nutrient Management2+	2+1
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## Theory

Soil fertility and soil productivity; nutrient sources - fertilizers and manures; essential plant nutrients - functions and deficiency symptoms. 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 lowland and upland conditions for high fertilizer use efficiency. 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. Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions. Sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium- factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers. Micronutrients - critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability. Common soil test methods for fertilizer recommendations; quantity- intensity relationships; soil test crop response correlations and response functions. Fertilizer use efficiency; blanket fertilizer recommendations - usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated nutrient management. Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

## Practicals

Principles of colorimetry, Flame-photometry and atomic absorption spectroscopy, Chemical analysis of soil for total and available nutrients, Analysis of plants for essential elements

## **Suggested References**

J.S. Kanwar et al., Soil Fertility Theory and Practice
Womwe, P.L and Swift, M.j., Soil Management of Tropical Soil Fertility Mengel K and Kirkby, EA., Principles of Plant Nutrition
ISSS, New Delhi., Fundamentals of Soil Science
Jackson, M.L., Soil Chemical Analysis
Dipak Sarkar and Abhijit Haldar., Fundamental Principles of Soil Science
Henry DF Boyd GE 2nd ed ., Soil fertility
Nyle C. Brady and Ray R Weil., Nature and propertices of soils

SAC 507	Management of Problematic Soils and Waters	1+1
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## Theory

Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible. Morphological features of saline, sodic and saline– sodic soils; characterization of salt–affected soils – soluble salts, ESP, pH; physical, chemical and microbiological properties. Management of salt– affected soils; salt tolerance of crops – mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils. 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. 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. Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

## Practicals

Characterization of acid, acid sulfate, salt–affected and calcareous soils, Determination of cations (Na+, K+, Ca2+ and Mg2+) in ground water and soil samples, Determination of anions (Cl–, SO 2–, CO 2–, and HCO –) in ground waters and soil samples, Lime and gypsum requirements of acid and sodic soils

## **Suggested References**

R Lal., Soil Quality and Soil Erosion Handbook No.60, USDA., Saline and Alkali Soils Nyle C. Brady and Ray R Weil., Nature and propertices of soils Chabbra R., Soil Salinity and Water Quality Henry DF Boyd GE 2nd ed ., Soil fertility

Soil, water and air pollution problems associated with agriculture, nature and extent. 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. Sewage and industrial effluents – their composition and effect on soil properties *f* health, and plant growth and human beings; soil as sink for waste disposal. Pesticides – their classification, behavior in soil and effect on soil microorganisms. Toxic elements – their sources, behavior in soils, effect on nutrients availability, effect on plant and human health. Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases – carbon dioxide, methane and nitrous oxide. Remediation *f* amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

## Practicals

Sampling of sewage waters, sewage sludge, solid*f* liquid industrial wastes, polluted soils and plants, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Air sampling and determination of particulate matter and oxides of sulphur, Visit to various industrial sites to study the impact of pollutants on soil and plants.

#### **Suggested References**

Dhyan Singh et al., Manual on Soil, plant and water analysis Ibrahim A Mirsal., Soil Polluation: Origin, Monitoring and Remediation James V Livingston., Agriculture and Soil Poullution KK Singh et al., Air, Water and Soil pollution Yaron et al., Soil pollution processes and dynamics Minkina et al Heavy metal compounds in soil Pradyot Patnaik., Handbook of environmental Analysis

# SAC 509Soil Testing & Fertilizer Recommendation1+1

#### Theory

Principles of soil testing; Factors affecting the availability of nutrients; Field sampling for soil testing. Testing soils for pH, plant nutrients, Lime and gypsum requirement; Interpretation of soil test results for fertilizer recommendation. Experimental methods for correlation and calibrating soil tests; The changing philosophy of soil test interpretation, Principles and practices in plant analysis; Leaf analysis as an aid in fertilizer recommendation; Operation and management of commercial soil testing and plant analysis laboratories; Concepts of soil testing and response studies in soil fertility evaluation; Visual and hidden hunger symptoms in plants and their diagnostic techniques; Crop logging techniques, biological methods in determining nutrients in soils; Mitscherlich pot culture methods for Neubauer techniques.

## Practicals

Collection soil samples from varying fertility levels, analysis, fertility ratings and computations of nutrient indices, Preparation of soil fertility maps, Fertilizer recommendation to crops based on soil test data: Use of soil test crop response concept in computing target yield of crops; Determination of available nutrients using pot culture method and Neubauer techniques.

## **Suggested References**

B.S. Stewart., Advance in siol science

Grewing J.R., Fertilizer recommendation Guide R.Lal and Stewart, B.A., Soil specific farming Fageria, N.K., The use of nutrients in crop plants

## Theory

Fertilizers – production, consumption and future projections with regard to nutrient use in the country and respective states. Manures– classification, chemistry, nutrient contents of bulky and concentrated organic manure. Manufacturing processes for different fertilizers (nitrogenous, phosphatic and potassic fertilizers) using various raw materials, characteristics and nutrient contents. Recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order. New and emerging issues in fertilizer technology – production and use of slow and controlled release fertilizers, supergranules fertilizers and fertilizers for specific crops *f* situations. Environmental pollution due to fertilizer use. Biofertilizers – important biofertlisers like Rhizobium, Azotobacter, Azospirilum, Micorrhiza Production efficiency and capacity utilization; quality control and legal aspects– fertilizer control order.

#### **Practicals**

Determination of moisture content in fertilizers, Qualitative tests of inorganic fertilizers, Determination of total nitrogen in fertilizers, Determination of water soluble P2O5 in fertilizer, Determination of water soluble K2O in K fertilizers, Analysis of manures for different nutrients, Determination of lime and gypsum contents in amendments, Visit to fertilizer quality control laboratories.

#### **Suggested References**

Basak R.K., A text book of fertilizers Gaur, AC et al., Organic manures IDFC., Fertilizer manual Shishir Sinha et al., Fertilizer Technology Sunilkumar and Ajay Bharath., Management of organic wastes Polprasert C., Organic wastes recycling Gustafson, A.F.,Hand of fertilizers

i	SAC 511	Agricultural Chemicals	1+1
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#### Theory

Definition, IUPAC approved terminology, statistics of production and consumption. Plant protection chemicals: Pesticides – classification of pesticides by different methods. Botanical insecticides, structure, properties, mode of action and uses of conventional insecticides such as nicotine, pyrethrins and rotenones. Structure, properties, mode of action and uses of Insecticides– chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids.

Fungicides – inorganic, organic– heterocyclic, formamide, alkane, alkane carboxylic acid and miscellaneous groups. Herbicides– classification and important groups– phenoxy compounds, substituted ureas, amides, thiocarbamates, triazines, pyridines, imidazolines and sulphonyl ureas. Nematicides – aliphatic halogen compounds, methyl isocyanate liberators, organophosphates and carbamates. Formulation of pesticides – definition, classification. Pesticide adjuvants: synergists. Pesticide residue: Concept definition, significance and analysis as per BIS specifications; Insecticide Act, Directorate of Plant Protection, Quarantine and Storage.

#### Practicals

pH, Acidityf Alkalinity, Bulk density, Wettability, Specific gravity, Suspensibility of pesticides, Titrimetric procedure for active ingredient analysis of Pesticide formulation, Extraction procedures for pesticide residues from soil and plant samples, Cleanup procedures for pesticide residues from soil and plant samples, Ultra– Violet (UV) Spectrophotometric methods in Pesticide, Infrared (IR) Spectroscopy, Thin Layer Chromatograph (TLC), Gas Chromatograph (GC) in Pesticide formulation *f* residue analysis, High Performance Liquid Chromatograph (HPLC) in Pesticide formulation *f* residue analysis, Studies on Bioassay techniques for Persistence of herbicides, Calculations, Reporting and Interpretation of the Pesticide Residue Data, Safety measures in handling pesticides, BIS standards for commonly used pesticides.

#### Suggested References

Cheng HH (Ed)., Pesticides in the Soil Environment: Processes, Impacts and Modelling Guenzi, W.D(Ed)., Pesticides in Soil and Water

Panda, H., Pesticides, Insecticides, fungicides and herbicides with formula and processes GWA Milne., Pesticides an introduction to 1800 pest controlling chemicals Roy MK., Chemistry of Pesticides

#### Theory

History, distribution, identification and description of soil erosion problems in India. Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity – estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation. Wind erosion– types, mechanism and factors affecting wind erosion; extent of problem in the country. Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures – their design and layout. Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi–arid regions, waterlogged and wet lands. Watershed management – concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds.

# Practicals

Determination of different soil erodibility indices – suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay fmoisture equivalent ratio, percolation ratio, raindrop erodibility index, Computation of kinetic

# **Suggested References**

Hudson Norman (3rd ed)., Soil Conservation Wallingford Soil resilience and sustainable land use Wischmeier., A guid to conservation planning

## SUPPORTING / MINOR COURSES FOR M.Sc., DEGREE PROGRAMMES AGRICULTURAL ECONOMICS

SL No	COURSE NO	COURSE TITLE	CREDIT HOURS
01	AEC 501	Intellectual Property Management	1+0
02	AEC 502	Commodity Futures Trading	2+0

AEC 501	Intellectual Property Management	1+0
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## Theory

World Trade Organization- Agreement on Agriculture (AoA) and Intellectual property rights (IPR) - Importance of Intellectual property management-IPR and Economic growth-IPR and biodiversity- Major areas of concern in intellectual property management- Technology transfer and commercialization- Forms of different intellectual properties generated by agricultural research. Discovery versus invention- patentability of biological inventionsmethod of agriculture and horticulture- procedure for patent protection: preparatory work, Record keeping. Writing a patent document, filing the patent document-types of patent applications-patent application under the Patent cooperation treaty (PCT). Plant genetic resources- importance and conservation- Sui Generic system- Plant Varieties Protection and Farmers Rights Act- registration of extinct varieties- Registration and protection of New VarietiesfHybridsfEssentiality derived varieties -Dispute prevention and settlement of Farmers' Rights. Trademark- Geographical indications of goods and commodities -copy rights-designs- biodiversity protection- Economic implications of Sanitary and Phytosanitary measures. Procedures for commercialization of technology -Valuation, costs and pricing of technologies-Licensing and implementation of Intellectual Properties-Procedures for commercialization -Exclusive and non exclusive marketing rights- Research exception and benefit sharing.

## **Suggested References**

- John T. Ramsay, 2011, Intellectual Property Management Best Practices, Publisher: LexisNexis Canada
- Derek Bosworth and Elizabeth Webster, 2006, The Management of Intellectual Property
- Erbisch FH and Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.

Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. Technology Generation and IPR Issues. Academic Foundation.

- Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
- 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.

History and Evolution of commodity markets – Terms and concepts: spot, forward and futures Markets – factors influencing spot and future markets. Transaction and settlement – delivery mechanism – role of different agents – trading strategies – potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets. Risk in commodity trading, importance and need for risk management measures – managing market price risk: hedging, Options, speculation, arbitrage, swaps – pricing and their features. Speculatory mechanism in commodity futures. Important global and Indian commodity exchanges – contracts traded special features – Regulation of Indian commodity exchanges – FMC and its role. Criticism of the future markets in agriculture in a country like INDIA. Fundamental Vs Technical analysis – construction and interpretation of charts and chart patterns for analyzing the market trend Market indicators – back testing. Introduction to technical analysis software – analyzing trading pattern of different commodity groups.

## **Suggested References**

Kaufman PJ. The Concise Handbook of Futures Markets: Jhon Wiley & Sons

Purcell WD. Agricultural Futures and Options: Principles and Strategies: MacMillan Publications

Wasendorf RR & McCaffery All About Commodities from the Inside Out. McGraw Hill

## AGRICULTURAL ENGINEERING, PROCESSING AND FOOD ENGINEERING

SL NO	COURSE NO	COURSE TITLE	CREDIT HOURS
01	PFE - 501	Food Processing Equipment and Plant Design	1+1
02	PFE - 502	Fruits and Vegetables Process Engineering	1+1

I	PFE 501	Food Processing Equipment and Plant Design	1+1
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#### Theory

Unit I :Design considerations of processing agricultural and food products.

- Unit II :Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation, membrane separation.
- Unit III :Human factors in design, selection of materials of construction and standard component, design standards and testing standards. Plant design concepts and general design considerations: Plant location, location factors and their interaction with plant location, location theory models, and computer aided selection of the location.
- Unit IV :Feasibility analysis and preparation of feasibility report; Plant size, factors affecting plant size and their interactions, estimation of break-even and economic plant size. Product and process design, process selection, process flow charts, computer aided development of flow charts.
- Unit V :Hygienic design aspects and worker's safety, functional design of plant building and selection of building materials, estimation of capital investment, analysis of plant costs and profitability's, management techniques in plant design including applications of network analysis, preparation of project report and its appraisal.

#### **Practicals**

Detailed design and drawing of mechanical dryers, milling equipment, separators, evaporators, mixers and separators. Each individual student will be asked to select a food processing plant system and develop a plant design report which shall include product identification and selection, site selection, estimation of plant size, process and equipment selection, process flow-sheeting, plant layout, and its evaluation and profitability analysis.

## Suggested References

Antonio LG and Gustavo VBC. 2005. Food Plant Design. CRC Press.

Couper. 2012. Chemical Process Equipment. Selection and Design Elsevier.

George S and Athanasios EK. 2015. Handbook of Food Processing Equipment. Springer.

Lloyd EB and Edwin HY. 1959. Process Equipment Design. Wiley-Interscience.

Michael MC. 2013. Food Plant Sanitation: Design, Maintenance, and Good Manufacturing Practices. CRC Press.

PFE 502	Fruits and Vegetables Process Engineering	1+1
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#### Theory

Importance of post harvest technology of fruits and vegetables, structure, cellular components, composition and nutritive value of fruits and vegetables, fruit ripening, spoilage of fruits and vegetables. Harvesting and washing, pre-cooling, preservation of fruits and vegetables,

blanching, commercial canning of fruits and vegetables, minimal processing of fruits and vegetables. Cold storage of fruits and vegetables, controlled atmosphere packaging of fruits and vegetables, gas composition, quality of storage. Dehydration of fruits and vegetables, methods, osmotic dehydration, foam mat drying, freeze drying, microwave heating, applications, radiation preservation of fruits and vegetables, irradiation sources. Intermediate moisture foods, ohmic heating principle, high pressure processing of fruits and vegetables, applications, sensory evaluation of fruit and vegetable products, packaging technology for fruits and vegetables, general principles of quality standards and control, FPO, quality attributes.

## **Practicals**

Determination of size, shape, density, area-volume-mass relationship of fruits and vegetables, sugar-acid ratio of fruits, evaluation of washer, grader and packaging methods, experiments on drying of fruits and vegetables, controlled atmosphere storage and quality evaluation.

## **Suggested References**

Bhatti S and Varma U. 1995. Fruit and Vegetable Processing. CBS.
Cruesss WV. 2000. Commercial Fruit and Vegetable Products. Agrobios Publisher.
Danthy ME. 1997. Fruit and Vegetable Processing. International Book Publisher.
Simson. 2016. Post-Harvest Technology of Horticultural crops. AAP.
Singh. 2018. Advances in Post-Harvest Technologies of Vegetable Crops. AAP.
Srivastava RP and Kumar S. 1994. Fruit and Vegetable Preservation. Principles and Practices. International Book Distr.
Thompson AK. 1996. Post Harvest Technology of Fruits and Vegetables. Blackwell.
Verma LR and Joshi VK. 2000. Post Harvest Technology of Fruits and Vegetables. Vols. I-

II. Indus Publisher.

SL	COURSE	COURSE TITLE	CREDIT
NO	NO		HOURS
01	SWE - 501	Design of Farm Irrigation Systems	2+1
02	SWE - 502	Soil and Water Conservation Engineering	1+1
03	SWE - 503	Watershed Management and Modeling	1+1
04	SWE - 504	Control of Pollution from Solid Wastes	2+0

#### SOIL AND WATER ENGINEERING

SWE 501	Design of Farm Irrigation Systems	2+1
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## Theory

Concepts of Irrigation; Irrigation principles, losses, conveyance, distribution; Application, scheduling parameters, water budgeting. Surface irrigation, hydraulics of water advance and recession, hydraulic resistance to flow, gravity irrigation. Design of Border irrigation, furrow irrigation, check basin irrigation; Sub Irrigation methods and concepts. Preliminary design criteria of sprinkler and micro irrigation systems, hydraulics of sprinkler and micro irrigation systems. Design of lateral, submain and main line of sprinkler and micro irrigation. Fertigation aspects. Underground water conveyance system; Evaluation of irrigation systems and practices.

## Practicals

Design and evaluation of border, furrow, check basin, sprinkler and micro irrigation, computation of frictional losses, Design of underground water conveyance systems, economics of irrigation methods, visit to irrigated farms.

#### **Suggested References**

Finkel HJ. 1983. Handbook of Irrigation Technology. Vols. I-II, CRC Press.

- James LG. 1988. Principles of Farm Irrigation System Design. John Wiley and Sons, New York, USA.
- Karmeli D, Peri G and Todes M. 1985. Irrigation Systems: Design and Operation. Oxford University Press.
- Michael AM. 2008. Irrigation Theory and Practices. Vikas Publishing House Pvt. Ltd, New Delhi. • Pillsbury AF. 1972. Sprinkler Irrigation. FAO Agricultural Development Paper No. 88, FAO.

Rydzewski. 1987. Irrigation Development Planning. John Wiley and Sons.

Sivanappan RK 1987. Sprinkler Irrigation. Oxford and IBH.

Sivanappan RK, Padmakumari O and Kumar V. 1987. Drip Irrigation. Keerthy Publ, House.

Probability and continuous frequency distribution; Fitting empirical distributions. Layout and planning of soil and water conservation measures; Design principles of soil and water structures including contour bunds and terraces; Gully control measures. Hydraulic jump and energy dissipaters for soil conservation structures; Hydrologic, hydraulic and structural design of drop structures. Sediment deposition process. Estimation of sediment load, earthen dams, seepage through dams and stability analysis. Rainwater harvesting, Flood control and stream bank protection measures.

## **Practicals**

Design of Drop spillway, chute spillway, drop inlet spillway, hydraulic jump calculation, design of bench terrace, contour bunds and contour trenches, design and problems on earthen dam, silt detention tanks and check dams, visit to soil conservation structures sites.

#### **Suggested References**

- Garg SK. 1987. Irrigation Engineering and Hydraulic Structures. Khanna Publishers, New Delhi.
- Kirkby MJ and Morgan PPC (eds). 1980. Soil Erosion. John Wiley and Sons. New York, USA.
- Mahnot SC, Singh PK and Chaplot PC. 2011. Soil and Water Conservation and Watershed Management. Apex Publishing House, Udaipur.
- Murty VVN. 1988. Land and Water Management Engineering. Second Edition Kalyani Publishers, New Delhi.
- Singh Gurmel C, Venkataraman G, Sastri and Joshi BP. 1991. Manual of Soil and Water conservation Practices. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.
- Suresh R. 2016. Soil and Water Conservation Engineering. Standard Publishers and Distributors, Delhi.

SWE 503	Watershed Management and Modeling	1+1
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#### Theory

Problems of desertification and degradation. Models of sediment yield. Survey, monitoring, reclamation and conservation of agricultural and forest lands, hill slopes and ravines. Concept of operational watershed. National land use policy, legal and social aspects. Watershed management research instrumentation and measurement, problem identification, simulation and synthesis. Modelling of flood and drought phenomenon, drought management and dry farming

1+1

## Practicals

Preparation of watershed development proposal, preparation of watershed evaluation report. Application of Models of flood and drought phenomenon. Application of watershed models.

#### **Suggested References**

- Dhaliwal GS Hansra BS and Ladhar SS. 1993. Wetlands, their Conservation and Management. Punjab Agricultural University, Ludhiana.
- Dhruvanarayana VV, Sastry G and Patnaik US. Watershed Management. Publ. and Inf. Dv., ICAR, Krishi Anusandhan Bhavan, New Delhi.
- Singh RV. 2000. Watershed Planning and Management. Second Edition Yash Publishing House, Bikaner.
- Suresh R. 2017. Watershed Planning and Management. Standard Publication and Distribution, Delhi.
- Tideman EM. 1999. Watershed Management (Guidelines for Indian Conditions). Omega Scientific Publishers, New Delhi.

SWE 504	Control of Pollution from Solid Wastes	2+0
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#### Theory

Definition, Sources, Quality, Classification and characteristics of solid waste collection, Transport and reduction at source. Handling, Collection, Storage, transport of Solid wastes. Disposal methods and their merits and demerits. Processing of solid wastes. Fertilizers, fuel and food values. Recycling and reuse materials and energy recovery operations.

#### **Suggested References**

- Bridgwater AV and Mum-ford CJ. 1979. Waste Recycling and Pollution Control Handbook. Van Nostrand Reinhold Company, New York.
- Kreith F and Tchobanoglous G. 2002. Handbook of Solid Waste Management. McGraw Hill Book Company, New York.
- Ramachandra TV. 2006. Management of Municipal Solid Waste. Capital Publication Company, New Delhi. • Tchobanoglous G, Theisenand H and Elliassen R. 1978. Solid Wastes. McGraw Hill Book Company, New York.

## AGRICULTURAL EXTENSION

SL NO	COURSE NO	COURSE TITLE	CREDIT HOURS
01	AEX 501	Development Communication and Information	1+1
		Management	
02	AEX 502	Diffusion and Adoption of Innovations	1+1

## AEX 501 Development Communication and Information Management 1+1

#### Theory

Communication process – concept, elements and their characteristics - Models and theories of communication - Communication skills- fidelity of communication, communication competence and empathy, communication effectiveness and credibility, feedback in communication, social networks and Development communication - Barriers in communication, Message - Meaning, dimensions of a message, characteristics of a good message, Message treatment and effectiveness, distortion of message. Methods of communication - Meaning and functions, classification. Forms of communication - Oral and written communication, Non-verbal communication, interpersonal communication, organizational communication. Key communicators - Meaning, characteristics and their role in development. Media in communication - Role of mass media in dissemination of farm technology, Effect of media mix for Rural People. Modern communication media - Electronic video, Tele Text, Tele conference, Computer Assisted Instruction, Computer technology and its implications. Agricultural Journalism as a means of mass communication, Its form and role in rural development, Basics of writing - News stories, feature articles, magazine articles, farm bulletins and folders. Techniques of collection of materials for news stories and feature articles; Rewriting Art of clear writing, Readability and comprehension testing procedures; photo journalism, communicating with pictures, Radio and TV Journalism, Techniques of writing scripts for Radio and TV.

#### **Practicals**

Exercises on Communication credibility, empathy, competence and communication skills. Visit to Press, Radio, AIR, Doordarshan, Press Trust of India, Tele Conference centre. Writing future articles, script writing for Radio, Script writing for TV, Measuring readability by using different formulae. Visiting progressive farmers to develop success stories.

#### **Suggested References**

- Andres D and Woodard J. 2013. *Social media handbook for agricultural development practitioners*. Publication by FHI360 of USAID. <u>http://ictforag.org/toolkits/</u> social/ SocialMedia4 AgHandbook.pdf
- Barber J, Mangnus E and Bitzer V. 2016. *Harnessing ICT for agricultural extension*. KIT Working Paper 2016: 4.

https://213ou636sh0ptphd141fqei1-wpengine.netdna-ssl.com/sed/wp-content/uploads/sites/ 2/2016/11/KIT\_WP2016-4\_Harnessing-ICT-for-agricultural-extension.pdf

- Bheenick K and Bionyi I. 2017. Effective Tools for Knowledge Management and Learning in Agriculture and Rural Development. CTA Working paper. https://publications.cta.int/media/publications/downloads/1986\_PDF.pdf
- Fafchamps M and Minten B. 2012. *Impact of SMS based Agricultural Information on Indian Farmers*. The World Bank Economic Review, Published by the Oxford University Press on behalf of the International Bank for Reconstruction and Development.
- FAO 2011. *E-learning methodologies a guide for designing and developing e-learning courses.*
- Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/015/i2516e/i2516e.pdf
- George T, Bagazonzya H, BallantyneP, Belden C, Birner R, Del CR and Treinen S. 2017. *ICT in agriculture: connecting smallholders to knowledge, networks, and institutions.* Washington, DC: World Bank.

https://openknowledge.worldbank.org/handle/10986/12613 16

- Heike Baumüller. 2018. The little we know: An exploratory literature review on the utility of mobile phone enabled services for smallholder farmers. *Journal of International Development*. 30, 134–154.
- Laurens K. 2016. *NELK Module 6: Basic Knowledge Management and Extension*, New Extensionist Learning Kit (NELK), Global Forum for Rural Advisory Services (GFRAS). <u>http://www.g-fras.org/en/knowledge/new-extensionist-learning-kit-nelk.html#</u> module-6-

Mayer RE. 2005. The Cambridge handbook of multimedia learning. New York: University of Cambridge.

MEAS & Access Agriculture 2013. A Guide to Producing Farmer-to-Farmer Training Videos. https://www.agrilinks.org/sites/default/files/resource/files/MEAS%20Guide%20to%

20Producing%20Farmer-to-Farmer%20Training%20 Videos%202013\_04.pdf Meera SN.2013. Extension, ICTs and Knowledge Management: The 10 difficult questions. Blog

15. Agricultural Extension in South Asia.

http://www.aesanetwork.org/extension-icts-and-knowledge-management-the-10-difficult- questions/

- Meera SN. 2017. Disruptive Technologies Big Data and Internet of Things in Strengthening Extension & Advisory Services. Blog 68. Agricultural Extension in South Asia. <u>http://www.aesanetwork.org/disruptive-technologies-big-data-and-internet-of-things-in-</u> strengthening-extension-advisory-services/
- Meera SN. 2018. A Treatise on Navigating Extension and Advisory Services through Digital Disruption. Blog 90. Agricultural Extension in South Asia. <u>http://www.aesanetwork.org/a-</u> treatise-onnavigating-extension-and-advisory-services-through-digital-disruption/
- Mittal N, Surabhi, Gandhi, Sanjay and Gaurav T. 2010. Socio-Economic Impact of Mobile Phones on Indian Agriculture. ICRIER Working Paper No. 246, Indian Council for Research on International Economic Relations (ICRIER), New Delhi.
- Preece J, Rogers Y, & Preece, J. 2007. Interaction design: Beyond human-computer interaction.

Chichester: Wiley.

- Saravanan R, Sulaiman RV, Davis K and Suchiradipta B. 2015. Navigating ICTs for Extension and Advisory Services. Note 11. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland. https://agrilinks.org/sites/default/files/resource/files/gfras-ggpnote11\_navigating\_icts\_ for\_ras\_1.pdf
- Saravanan R and Suchiradipta B. 2015. *mExtension Mobile Phones for Agricultural Advisory Services*. Note 17. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.
- <u>www.g-fras.org/en/download.html?download=349:</u> ggp-note-17-mextension-mobile-phones- foragricultural-advisory-services
- Saravanan R and Suchiradipta B. 2016. *Social media policy guidelines for agricultural extension and advisory services*, GFRAS interest group on ICT4RAS, GFRAS: Lindau, Switzerland. <u>www.g-fras.org/en/knowledge/gfras-publications.html?download</u>=415: social-media-policy-guidelines-for-agricultural-extension-and-advisory-services

- SaravananR. 2010. (Ed.) ICTs for Agricultural Extension: Global Experiments, Innovations and Experiences, New India Publishing Agency (NIPA), New Delhi. <u>http://www.saravananraj.net/wp-content/uploads/2014/12/32\_India\_ICTs-for-Agricultural-</u> Extension\_Saravanan.pdf
- Saravanan R, Suchiradipta B, Chowdhury A, Hambly OH and Hall K. 2015. Social Media for Rural Advisory Services. Note 15. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.
- <u>www.g-fras.org/en/download.html?download=355:</u> ggp-note-15-social-media-for-rural- advisoryservices
- Saravanan R, Suchiradipta B, Meera SN, Kathiresan C and Anandaraja N. 2015. *Web Portals for Agricultural Extension and Advisory Services*. Note 16. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.
- <u>www.g-fras.org/en/download.html?download=356:</u> gfras-ggp-note-16-web-portals-for- agriculturalextension-and-advisory-services
- Saravanan R.2014. (Ed.). Mobile Phones for Agricultural Extension: Worldwide mAgri Innovations and Promise for Future, New India Publishing Agency, New Delhi.
- http://www.saravananraj.net/wp-content/uploads/2014/12/27 Mobile-phones-for-Extension-in-India\_Saravanan-Raj-Draft.pdf Agricultural-
- Technology for Agriculture and Rural Development, New India Publishing Agency (NIPA), New Delhi.
- Sophie T and Alice VDE.2018. Gender and ICTs Mainstreaming gender in the use of information and communication technologies (ICTs) for agriculture and rural development, FAO. http://www.fao.org/publications/card/en/c/I8670EN
- Suchiradipta B and Saravanan R. 2016. Social media: Shaping the future of agricultural extension and advisory services, GFRAS interest group on ICT4RAS discussion paper, GFRAS: Lindau, Switzerland.
- <u>www.g-fras.org/en/knowledge/gfras-publications.html?</u> download=414: social-media- shaping-thefuture-of-agricultural-extension-and-advisory-services
- Vignare K. 2013. Options and strategies for information and communication technologies within agricultural extension and advisory services. MEAS Discussion paper. http://meas.illinois.edu/wpcontent/uploads/2015/04/Vignare-K-2013-ICT-and-Extension-MEAS-Discussion-Paper.pdf
- World Bank. 2017. ICT in Agriculture (Updated Edition): Connecting Smallholders to Knowledge, Networks, and Institutions. Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/27526

#### Websites

- FAO-Food and Agricultural Organisation (Research and Extension) <u>http://www.fao.org/research-and-extension/en/</u>
- **CTA**–The Technical Centre for Agricultural and Rural Cooperation: Digitalization– https://www.cta.int/en/channel/digitalisation-sid05951b8c7-e611-4f34-9ae6-8c0fc0c822bc
- GFRAS-Global Forum for Rural Advisory Services- http://www.g-fras.org/en/
- AESA-Agricultural Extension in South Asia- http://www.aesanetwork.org/

<b>AEX 502</b>	Diffusion and Adoption of Innovations	1+1
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#### Theory

Diffusion – concept and meaning, elements; traditions of research on diffusion; the generation of innovations; innovation-development process; tracing the innovation-development process, converting research into practice. The adoption process- concept and stages, dynamic nature of stages, covert and overt processes at stages, the innovation-decision process – a critical appraisal of the new formulation. Adopter categories – Innovativeness and adopter categories,

adopter categories as ideal types, characteristics of adopter categories; Perceived attributes of Innovation and their rate of adoption, factors influencing rate of adoption. Diffusion effect and concept of over adoption, opinion leadership measurement and characteristics of opinion leaders, monomorphic and polymorphic opinion leadership, multi-step flow of innovation; concepts of homophily and heterophily and their influence on flow of innovations; Types of innovation-decisions – Optional, Collective and Authority and contingent innovation decisions; Consequences of Innovation– Decisions – Desirable or Undesirable, direct or indirect, anticipated or unanticipated consequences; Decision making – meaning, theories, process, steps, factors influencing decision making.

#### **Practicals**

Case studies in individual and community adoption process, content analysis of adoption studies, Identification of adopter categories on a selected technology, study of attributes of current farm technologies, Identification of opinion leaders, Sources of information at different stages of adoption on a selected technology, study of factors increasing or retarding the rate of adoption, presentation of reports on adoption and diffusion of innovations.

## **Suggested References**

Dasgupta. 1989. Diffusion Agricultural Innovations in Village India. Wiley Eastern.

Jalihal KA & Veerabhadraiah V. 2007. Fundamentals of Extension Education and Management in Extension. Concept Publ. Co.

Ray GL. 2005. Extension Communication and Management. Kalyani Publ.

Reddy AA. 1987. Extension Education. Sree Lakshmi Press, Bapatla.

Rogers EM. 2003. Diffusion of Innovations. 5th Ed. The Free Press, New York.

AGRICULTURAI	MARKETING AND	COOPERATION
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SL NO	COURSE NO	COURSE TITLE	CREDIT HOURS
01	AMC 501	International Business	2+0
02	AMC 502	Agricultural and Food Marketing	2+1
03	AMC 503	Grading and Quality Control in Agricultural and Food Industry	1+1

AMC 501	International Business
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2+0

#### Theory

Introduction-Evolution-Nature of International Business- Why go International- Stages of Internationalization- International Business. Approaches-Theories of International Business -Competative advantage of Global business-Problems of international business- competative advantage in a Global setting. International Business Environment-Introduction- Social and Cultural Environment-Technological Environment-Economic Environment- Political Environment. Modes of Entering International Business- International Business Analysis- Modes of Entry: Exporting, licensing, franchising, contract manufacturing, management contracts, turnkey projects, foreign direct investment, alliances like mergers and acquisitions, joint ventures-Comparison of Different Modes of Entry- Functional Alliances- Managing Conflict Situations- Break up of Alliances. Globalization- Introduction- Meaning and Definition- Features- Stages of Globalization- Globalization of Markets, Production, Investment and Technology- Globalization : Is it Desirable?- Advantages and Disadvantages- Methods of Globalization- Essential Conditions for Globalization -Globalization and India. Multinational Corporations-Definition- Distinction among IC, MNC, GC and TNC- Factors Contributed for the Growth of MNCs- Advantages and Disadvantages of MNCs- Control over MNCs- Organization Design and Structure of MNCs, Relationship between Headquarters and Subsidiaries- MNCs in India- The Indianisation of Transnational. Foreign Direct Investment- Introduction- Foreign Direct Investment in the world economy- Trends in FDI- The direction of FDI-The source of FDI- The form of FDI: Acquisitions versus Green Field Investments- Horizontal Foreign Direct Investment- Vertical Foreign Direct Investment- Focus on Managerial Implications.

## **Suggested References**

Chadha GK. 2003. WTO and Indian Economy.

Deep & Deep. Economic Survey of India. Ministry of Finance, Govt. of India. (various issues)

HAU 2003. Refresher Course on Technological Interventions to Face WTO Challenges.

- AAREM & HRD CCS HAU Hisar. Indian Journal of Agricultural Economics
- Vasisht AK & Singh Alka. 2003. WTO and New International Trade Regime-Implication for Indian Agriculture. Advance Publ. Concept.

Definition and concept, role of marketing in economic development, classification of markets. Approaches to study marketing system-functional- institutional-commodity and structural approaches. Marketing channels and price spread. Marketing Efficiency-Technical Economic Efficiency. Evaluation of and marketing efficiency-structure-conduct and performance, marketing margin and price spread, market integration method. Analysis of marketing systems for a) food grains b) commercial crops c) horticultural crops d) livestock and animal products, and f) agricultural inputs. Food consumption and marketing - Food preferences, consumption and expenditure patterns, demographics of food consumption - Food processing and manufacturing - Innovations and branding in food manufacturing, the structure of food manufacturing industry, location of food processing and problems of food processors. Food wholesaling and retailing - Food wholesaling, food retailing, competition and pricing in food retailing, the food service market. Government and institutional role in agricultural and food marketing - Market Legislation and Regulation, Commodity Boards and Corporations, Marketing Co-operatives.

#### **Practicals**

Identification of Marketing Channels and Analysis of Price Spread. Evaluation of Marketing Efficiency – Temporal Efficiency, Spatial Efficiency and Structure – Conduct – Performance Analysis. Market integration studies Performance evaluation of Marketing Boards, Co–operatives and other Marketing parastatals.

#### **Suggested References**

- Kotler P, Keller K, Koshy A and Jha M. 2013. Marketing Management–Analysis, Planning, Implementation and Control. Pearson Education.
- Ramaswamy VS. 2017. Marketing Management: A Strategic Decision Making Approach McGraw Hill Education
- Saxena R. 2009. Marketing Management. Mc Graw Hill.4th Edition
- William Perreault Jr., Mccarthy E. Jerome., 2006, Basic Marketing: A Global Marketing Approach, Tata McGraw Hill
- Gay R, Cjarlesworth A, Esen R. 2014, Online Marketing, Oxford University Press Mohammed, Fisher, Jaworski and Cahill: Internet Marketing – Building Advantage in a networked economy Tata McGraw-Hill
- Strauss J and Frost R. 2013. E-Marketing, Prentice-Hall Roberts M. 2018. Internet Marketing, Cengage Learning Vassos: Strategic Internet Marketing – Practicalse-commerce and branding Tactics, Que Books
- Chaffey, Meyer, Johnston and Ellis Chadwick. 2009. Internet Marketing, Prentice-Hall/ Financial Times
- Acharya SS and Agarwal NL. 2011. Agricultural Marketing in India. 4th Ed. Oxford and IBH.Kohls RL and Uhj JN. 2005. Marketing of Agricultural Products. 9th Ed. Prentice Hall. Mohan J. Agri-Marketing Strategies in India, NIPA

Sharma Premjit. 2010. Agri-Marketing Management, Daya Publishing House

## AMC 503Grading and Quality Control in Agricultural and Food Industry1+1

#### Theory

Standardization and Grading – Its meaning scope and importance. Institutions related to standardization and grading. ISO (International organization for standardization). Bureau of Indian standards, Directorate of Marketing and Inspection, Objectives and functions and their role in standardization. Grading of food grains, pulses, commercial crops, oil seeds, spices, horticultural produce, fruits and vegetables. Grading of livestock, poultry, fisheries. Food adulteration and food poisoning and detection, food hygiene. Sanitary and phytosanitory measures. Quality management, quality parameters, quality specifications. Total quality management.

## **Practicals**

Introduction to grading laboratory, study of sampling and grading instruments, principles of sampling, estimation of moisture in food grains by Hot air Oven method, infrared moisture balance method. Estimation of different refractions in important cereals. Physical analysis of pulses and oil seeds. Detection of some common adulterants in foods by simple and quickest methods. Visit to DMI, Regional Agmark laboratory, Bureau of Indian Standards for food safety industry and analytical quality control.

#### **Suggested References**

- J. L. Multon, 1995, Quality Control for Food and Agricultural Products, published by Wiley.
- https://dmi.gov.in/ (Directorate of Marketing & Inspection, Ministry of Agriculture and Farmers Welfare Government of India

SL NO	COURSE NO	COURSE TITLE	CREDIT HOURS
01	AMB 501	Microbiological Techniques	0+2
02	AMB 502	Soil Microbiology	2+1
03	AMB 503	Industrial Microbiology	1+1
04	AMB 504	Biofertilizer Technology	1+1
05	AMB 505	Biology and Production of Mycorrhizae	2+1
06	AMB 506	Food Microbiology	2+1

## AGRICULTURAL MICROBILOGY

AMB 501	Microbiological Techniques
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#### Practicals

- Awareness about lab safety measures
- Study of general microbiological equipment, cleaning of glassware and apparatus for laboratory use
- Methods of sterilization used in microbiology laboratory
- Use of simple techniques in laboratory (Colorimetry, Centrifugation, electrophoresis and chromatography)
- Types of culture media
- Isolation techniques and direct microscopic count
- Environmental factors affecting bacterial growth: physical chemical, temperature, pH, osmotic pressure, light (UV) and bacteriostatic agents. Bacteriology of air, water, and soil.
- Characteristics of important types of micro-organisms: major functional groups of bacteria, lactic acid, spore forming and coliforms bacteria, fungi, yeast and mold.
- Assessment of microbial quality of portable water.
- Working in microscope

#### **Suggested References**

Roy A.K. 2010. Laboratory Manual of Microbiology (PracticalsManual Series).

- Goldman E and Green LH. 2015. *PracticalsHandbook of Microbiology*. 3rd Edition. http/ www. CRC press life science Microbiolgy
- Brock, T.D. 2008. *Biology of microorganisms* (Ed.) Madigan MT, Martinko J M, Dunlap P V, Clark D.P., 12th ed. Pearson, New Jersey.
- Pelczar, M.J. Jr., Chan, E.C.S. and Kreig, N.R. 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., DeIhi.
- 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

0+2

# Tortora, G.J., B.J. Funke and C.L. Case. 2010. *Microbiology: an introduction*.10th Ed. Benjamin Cummings., New York.

# Websites http://www.asmscience.org, http://www.asm.org, http://www.microbiologyonline.org.uk, http://www.microbeworld.org

AMB 502Soil Microbiology2-	+1
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## 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
- N<sub>2</sub> 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

#### **Suggested References**

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 (Edrs). 2006. *Microbial Root Endophytes*. Pub Springer.
- Magesin R and Schinner F. (Edrs). 2005. *Manual of soil analysis monitoring and assessing soil Bioremediation*. Pub: Springer.
- Pinton R, Varanini Z and Nannipiers 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 n the Rhizosphere*. Pub: Springer.

Websites <u>www.nature.com</u>, <u>www.microbiologysociety.org</u>, <u>www.sare.org</u>

AMB 503	Industrial Microbiology	1+1
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#### Theory

Biofermentor. Production of wine, beer, lactic acid, acetic acid (vinegar), citric acid, antibiotics, enzymes, vitamins, single cell proteins. Vaccines. Bioagents and Biopesticides. Bioplastics and biopolymers: Microorganisms involved in synthesis of biodegradable plastics, other pigments, Biosensors: Development of biosensors to detect food contamination and environment pollution. Biomining: Coal, mineral and gas formation, prospecting for deposits of crude, oil and gas, recovery of minerals from low–grade ores.

#### Practicals

Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery. Detection of food-borne pathogens, pesticide degradation. Demonstration of biogas production. Production of biocontrol agents. Microbial analysis of processed foods

# **Suggested References**

- Sylvia DM, Fuhrmann JJ, Hartlly PT and Zuberer D. 2005. *Principles and Applications of Soil Microbiology*. 2nd Ed. Pearson Prentice Hall Edu.
- Waites, M.J., Morgan, N.L., Rockey, J.S. and Higton, G. (2002). *Industrial Microbiology: An Introduction.* Blackwell Science Publishers.
- Crueger W and Crueger A. *Biotechnology: A Text Book of Industrial Microbiology* Panima Publishing Corporation.

Reed G. 1999. Prescott and Dunn's Industrial Microbiology. CBS Publishers.
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- Forciniti D. 2008. *Industrial Bioseparations: Principles and Practice*. 1st Edition, Wiley-Blackwell. *Microbiology*, American Society of Microbiology, Washington.
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- ElMansi EMT, Bryce CFA, Dahhou A, Sanchez S, Demain AL, Allman AR. 2012. *Fermentation Microbiology and Biotechnology* 3rd Ed. CRC Press, Taylor and Francis, Boca Raton.
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#### Websites

https://www.biomerieux.com/en/industrial-microbiological-control-0 https://icar.org.in/content/food-and-industrial-microbiology

### Theory

Agriculturally important beneficial microorganisms - free living, symbiotic (rhizobial, actinorhizal) nodule formation, competitiveness and quantification of N2 fixed, associative and endophytic nitrogen fixers including cyanobacteria, taxonomic classification,. Phosphate solubilizing bacteria and fungi and mycorrhiza. Potash solubilizing *f* mobilizing microbes.Plant growth promoting rhizobacteria. Microbial biocontrol agents. Beneficial microorganisms for recycling of organic waste and composting, Bioremediators and other related microbes. Other agriculturally important beneficial microorganisms selection, establishment, competitiveness, crop productivity, soil and plant health. Large scale production of biofertilizers Different formulations of biofertilizers. Quality control of microbial inoculants. Marketing of biofertilizers .Methods of biofertilizer application.

## Practicals

Isolations of symbiotic, asymbiotic, associative nitrogen fixating bacteria. Development and production of efficient microorganisms, Determination of beneficial properties in important bacteria to be used as biofertilizer, Nitrogen fixing activity, P and K solubilization by microbes. Estimation of AM fungal spores and percent infection in roots. Testing for Indole acetic acid (IAA), GA, Cytokinins and siderophore production by beneficial microorganisms. Biofertilizer production and quality control.

### **Suggested References**

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Kannaiyan S and Kumar K. 2005. Azollabiofertiliser for sustainable Rice Production. Daya Publishing House, Delhi.

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Journals

Journal of Biofertilizer & Biopesticides

Journal of Botanical Sciences

Websites

Biofertilizer in organic Agriculture (www.Journalphytology.com)

Microbial biofertilizers (www.Boffinaccess.com)

- Biofertilizer as a prospective input for sustainable agriculture in India. http://www.krishisewa.com/articles/organic-agriculture/115biofertilizers.html
- Handbook of Microbial Biofertilizers M. K. Rai, PhD Editor Pub: Food Products Press, NY.

Bio fertilizers

https://www.worldcat.org/search?q=biofertilisers&fq=dt%3Abks&dblist=638 &qt =sort&se= yr&sd=desc&qt=sort\_yr\_desc

AMB 505Biology and Production of Mycorrhizae2+1	AMB 505	ology and Production of Mycorrhizae 2+1	
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### Theory

Type of mycorrhizae-ecto, vesicular-arbuscular, Ericoid and orchidaceous mycorrhizae, their occurrence. distribution and significance in natural ecosystem. Ectomycorrhizae-fungi involved, their morphology ecology and physiology. Methods of inoculation-plant response to inoculationmechanism of improved plant growth. Production of the VA mycorrhizae inoculums and its application. Vesicular-arbuscular mycorrhizae taxonomy pf the fungi, morphology and histology, quantification in plnat roots and in soil. Isolation, axenic and pot culture. Procedures for inoculation, plant response to colonizations. Physiology and ecology of the symbiosis. Biological interactions with other soil flora and fauna. Mass multiplication techniques. Exploitation of mycorrhizae in agriculture, horticulture and forestry.

## Practicals

Quantification of mycorrhizae in plant roots: methods for the recovery of mycorrhizal propegules from soil: spore germination and axenic culture of endomycorrhizae; production of endomycorrhizal inoculums; evaluation of plant responses to mycorrhizal inoculation Study tour to collect samples for isolation and identification of mycorrhizal fungi.

## **Suggested References**

The mycorrhizae Diversity, Ecology and Applications 2008, M. Tiwari & S.C. Sati (Auditors), Daya Publishing House Delhi

Fundamentals of mycorrhizal biology and Biotechnology 2002, Ramarao Pannuri, Agrotech Publishing Academy, Udaipur

AMB 506	Food Microbiology	2+1
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#### 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. Foodborne 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 infoods. 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

## Suggested References

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.
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- Doyle, M.P. and Beuchat, L. R. 2007. Food Microbiology- Fundamentals and Frontiers, ASM Press.
- Garbutt, J., 1997. *Essentials of Food Microbiology*, Armold 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

## AGRONOMY

SL NO	COURSE NO	COURSE TITLE	CREDIT HOURS
01	AGR 501	Agrometeorology and Crop Weather Forecasting	2+1
02	AGR 502	Crop Growth and Yield Analysis	1+1

AGR 501	Agrometeorology and Crop Weather Forecasting	(2+1)
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## Theory

Agro meteorology – aim, scope and development in relation to crop environment; composition of atmosphere, distribution of atmospheric pressure and wind. Characteristics of solar radiation; energy balance of atmosphere system; radiation distribution in plant canopies, radiation utilization by field crops; photosynthesis and efficiency of radiation utilization by field crops; energy budget of plant canopies; environmental temperature: soil, air and canopy temperature. Temperature profile in air, soil, crop canopies; soil and air temperature effects on plant processes; environmental moisture and evaporation: measures of atmospheric temperature and relative humidity, vapor pressure and their relationships; evapo-transpiration and meteorological factors determining evapotranspiration. Modification of plant environment: artificial rain making, heat transfer, controlling heat load, heat trapping and shading; protection from cold, sensible and latent heat flux, controlling soil moisture; monsoon and their origin, characteristics of monsoon; onset, progress and withdrawal of monsoon; weather hazards, drought monitoring and planning for mitigation. Weather forecasting in India short, medium and long range; aerospace science and weather forecasting; benefits of weather services to agriculture, remote sensing; application in agriculture and its present status in India; atmospheric pollution and its effect on climate and crop production; climate change and its impact on agriculture.

### **Practicals**

Visit to agro-meteorological observatory to record sun-shine hours, wind velocity, wind direction, relative humidity, soil and air temperature, evaporation, precipitation and atmospheric pressure; Measurement of solar radiation outside and within plant canopy; Measurement *f* estimation of evapo-transpiration various by methods; Measurement festimation of soil water balance; Rainfall variability analysis: Determination of heat-unit requirement for different crops; Measurement of crop canopy temperature; Measurement of soil temperatures at different depths; Remote sensing and familiarization with agro-advisory service bulletins; Study of synoptic charts and weather reports, working principle of automatic weather station; Visit to solar observatory.

### **Suggested References**

Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
Kakde JR. 1985. Agricultural Climatology. Metropolitan Book Co.
Mahi and Kingra. 2014. Fundamentals of agrometeorology. Kalyani publishers.
Mavi HS and Tupper. 2004. Principles and applications of climate studies in agriculture. CRC Press Varshneya MC and Pillai PB. 2003. Text Book of Agricultural Meteorology. ICAR.

Watts A. 2005. Instant Weather Forecasting. Water Craft Books.

- Ram Sastry AA. 1984. Weather and Weather Forecasting. Publication Division, GOI, New Delhi.
- Singh SV, Rathore LS and Trivedi HKN. 1999. A Guide for Agrometeorological Advisory Services. Department of Science and Technology, NCMRWF, New Delhi.
- Wegman and Depriest. 1980. Statistical Analysis of Weather Modification Experiments. Amazon Book Co.Journals Journal of Agrometeorology Italian Journal of Agrometeorology

Agricultural and Forest Meteorology • Current Science

## Websites

http://www.imd.gov.in/pages/main.php http://www.fao.org/home/en/ • www.wmo.org • www.ipcc.org Journal of Climatology and Weather Forecasting Theoretical and Applied Climatology Atmospheric Research Journal Journal of Agrometeorology Agroclimatology

AGR 502	Crop Growth and Yield Analysis	(1+1)

## Theory

Crop growth and development, Growth expressions in plants. Growth measurements. History and development of important growth indices and forms of growth analysis in field crops. Genesis of crop yield, formation of yield components. Plant density and yield relationships in crops- density equations. The senescence of leaf, leaf area and leaf area duration, chlorophyll content, development of primordium, chloroplast and their relation to dry matter production and yield. Accumulation and distribution of dry matter-partition analysis of crop plants, contribution of each part to economic yield. Factors determining yields. Use of growth analysis technique to study variation in yield due to planting season, planting density, fertilizer treatment, other agronomic practices, light, temperature, water, growth substances, varietal differences. Crop response curves. Dynamics of crop growth and modeling.

### Practicals

Partitional analysis of dry matter production and accumulation in different crops. Patterns of nutrient contents and dry weight accumulation of whole plants (%) and in different parts. Dry matter accumulation (% of total) curves and their importance in crop growth and development of the plant. Methods of measuring leaf area and estimation of leaf production constant (factor) in different crops. Estimation of leaf area and leaf angle at different profiles in different crops. Estimation of dry matter production (gfplant) and accumulation (% to total). Estimation of LA*f*plant (cm2), Leaf area index (LAI) and leaf area duration (LAD, days). Estimation of Absolute growth rate (AGR, gfplant*f* day), Daily rate of DM production and relative growth rate (RGR, gfday). Estimation of leaf

area ratio (LAR), Relative growth rate of leaf (RGRL), leaf weight ratio (LWR) and Specific leaf area (SLA). Computation of growth indices for the given primary data and presentation of these through tables and graphs. Estimation of Net assimilation rate (NAR, gfdm2fday by Gregory's method (Ea) and whitehead and Myers cough's method (E'a) and Crop growth rate (CGR, gfcm2fday). Study on light transmission and radiation measurements in relation to canopy analysis studies (Co– efficient of solar energy utilization). Estimation of chlorophyll content in different crops and relating them to growth and yield thorough chlorophyll index. Computation of biological yield, harvest index (HI), Grain to leaf ratio and dry matter efficiency (DME). Study of relationship between growth and yield components in expression of ultimate yield in different crops. Working out crop response curves. Working out crop growth – modeling.

### **Suggested References**

Basics of Organic Farming: by Mamta Bansal. Kindle Edition

The Complete book of Organic farming and products of organic compost: NPCS Board of consultants and Engineers.

ABC of Organic Farming: Amitava Rakshit and H.B. Singh. Jain Brothers.

## **CROP PHYSIOLOGY**

SL NO	COURSE	COURSE TITLE	CREDIT
	NO		HOURS
01	CPH 501	Principles of Plant Physiology - II Metabolic	2+1
		Processes and Growth Regulation	
02	CPH 502	Morphogenesis, Tissue Culture and Transformation	1+1
03	CPH 503	Experimental Techniques in Plant Physiology	0+1
04	CPH 504	Physiology of Woody Plants	2+0

CDII 501	Principles	of	Plant	Physiology-II:	Metabolic	Processes	and	(2 + 1)
CPH 501	Gi	row	th Reg	ulation				(2+1)

## Theory

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 II:

Carbon Metabolism: Biochemical Processes, CO<sub>2</sub> diffusion mechanisms and diffusive conductance, concept of Ci 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 C4and CAM photosynthesis, Product synthesis, Starch and Sucrose biosynthesis.

Unit III:

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 IV:

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 V:

- Nitrogen Assimilation and Protein Synthesis
- Developments in d-nitrgen fixation
- Nitrate reduction and assimilation GS-GOGAT process for amino acid synthesis

• Inter-Dependence of carbon assimilation and nitrogen metabolisms

Unit VI:

- 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 VII: 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 VIII: Synthetic Growth Promoters

- Different synthetic hormones: Salicylic acid, strigolactonesetc
- Roles and biological activities of various synthetic hormones
- Commercial application of hormones to maximize growth and productivity

Unit IX: 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

# Suggested References

- Kirchhoff H. 2019. Chloroplast ultrastructure in plants, New Phytologist. Doi.org/10.1111/ nph.15730
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- Mus, F., Crook, M. B., Garcia, K., Costas, A. G., Geddes, B. A., Kouri, E. D.andUdvardi, M.
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- 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., andAsami, T. 2018. Chemical regulators of plant hormones and their applicationsin basic research and agriculture. Bioscience, biotechnology, and biochemistry, 82(8), 1265-1300.
- Zwanenburg, B., Pospíšil, T., and Zeljkoviæ, S. Æ. 2016. *Strigolactones: new plant hormones in action. Planta*, 243(6), 1311-1326.
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- Gururani, M., Mohanta, T., and Bae, H. 2015. Current understanding of the interplay between phytohormones and photosynthesis under environmental stress. International journal ofmolecular sciences, 16(8), 19055-19085.
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## **General Text books**

Taiz, Lincoln, Zeiger. 2007 Plant Physiology, Eduardo Original American edition Sinauer Associates, Inc., 2006; 4th ed., XXVI, ISBN: 978-3-8274-1865-4; © Springer.Plant Physiology Frank Boyer Salisbury and Cleon Ross.

Introduction to Plant Physiology (Wie) by William G. Hopkins.

CPH 502	Morphogenesis, Tissue Culture and Transformation	1+1	
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### Theory

Morphogenesis: The cellular basis of growth and morphogenesis cytodifferentiation. The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and cellular totipotency. Introduction to in vitro methods : Terms and definitions, Use of growth regulators, Beginning of in vitro cultures in our country (ovary and ovule culture, in vitro pollination and fertilization), Embryo culture, embryo rescue after wide hybridization and its application, Endosperm culture and production of triploids. Introduction to the processes of embryogenesis and organogenesis and their Practicalsapplications: Clonal Multiplication of elite species (micropropagation) - axillary bud, shoot tip and meristem culture. Haploids and their applications. Somaclonal variations and applications. Introduction to protoplast isolation: Principles and applications. Testing of viability of isolated protoplast. Various steps in the regeneration of protoplast. Somatic hybridization - an introduction, Various methods for fusing protoplast, chemical and electrical. Use of makers for selection of hybrid cells. Practicalsapplications of somatic hybridization (hybrids vs cybrids). Use of plant cells, protoplast and tissue culture for genetic manipulation of plant : Introdiuction to A. tumefaciens. Tumour formation on plants using A. tumefaciens (Monocots vs Dicots), Root - formation using A. rhizogenes.

## Practicals

Tissue culture laboratory orientation, facilities required, glassware, stock preparation, media preparation, aseptic manipulation in tissue culture lab, explants preparation for aspetic inoculation. In vitro culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes; Effect of explant age on propagation potential, Effect of growth regulators auxin, cytokinins and ethlyne on callus induction, organogenesis; Somatic embryogenesis, Effect of growth conditions such as temperature and photoperiod on organogenesis, Single – cell suspension cultures.

Bajaj YPS. (Ed.). 1991. Biotechnology in Agriculture and Forestry. Vol. XIV. Springer-Verlag. Rajdan MK. 1993. Plant Tissue Culture. Oxford & IBH.

CPH 503	Experimental Techniques in Plant Physiology	0+1
0111 000		• · <del>-</del>

### **Practicals**

**Ouantification** of immunoassay*f*physico-chemical hormone methods. WUE-determination of water use efficiency by gravimetric approach. Stable isotopes-use in physiological investigations. Use of isotope materials (potential photosynthesis *f* protein synthesis). Purification, quantification of RuBisCO by ELISA using polyclonal antibodies. Gas exchange technique, measurement of photosynthetic rates and dark respiration. Protein purification and isozyme analysis. Moisture fTermperature stress - methods to impose, quantification of the stress levels. Molecular aspects of stress response - stress responsive proteins, their expression - western and northern analysis. Stress measurement parameters (membrane integrity, chlorophyll stability index, osmolyte quantification, osmotic adjustment. TTC, etc.,). DNA extraction and determination of polymorphism-RAPD, RFLP, and AFLP. Real - time PCR, Flourimetry. RNA isolation. Reverse Northern. cDNA library. Fluorescence kinetics and their application in physiology.

### **Suggested References**

- Alonso JM, Stepanova AN. 2015 (Eds.) Plant Functional Genomics, Methods and Protocols
- Costa, Miguel and Grant, Olga and Chaves M. 2013. Thermography to explore plantenvironment interactions. Journal of Experimental Botany 64. 10.1093/jxb/ert029.
- DeBlasio, Stacy L., Anne W. Sylvester, and Jackson D. 2010. Illuminating plant biology: using fluorescent proteins for high-throughput analysis of protein localization and function in plants. Briefings in Functional Genomics 9 (2): 129-138.
- Fung TH, WeiwenXue V, Koh SP, Chiu YM, Ng LP and Wong SC. 2017. NanoString, a novel digital color-coded barcode technology: current and future applications in molecular diagnostics. Expert review of molecular diagnostics 17 (1): 95-103.
- Jones Jr, Benton J. 2016. Hydroponics: a Practicalsguide for the soilless grower. CRC press.
- Kahl G and Khalid M (eds.). 2008. The handbook of plant functional genomics: concepts and protocols. John Wiley and Sons.
- Leister D. 2004. 1st Edition Plant Functional Genomics
- Ljung K, Sandberg G, Moritz T. 2010. Methods of Plant Hormone Analysis. Davies P.J. (eds) Plant Hormones. Springer, Dordrecht
- Maxwell K and Giles NJ. 2000. Chlorophyll fluorescence—a Practicalsguide. Journal of Experimental Botany 51 (345): 659-668.
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- Qian F, Hong H, Zhao L, Kukolich S, Yin K and Wang C. 2018. Visible and nearinfrared reflectance spectroscopy for investigating soil mineralogy: a review. Journal of Spectroscopy.
- Rimantas K, Kojima M, Nishiyori H, Nakamura M, Fukuda S, Tagami M, Sasaki D et al. 2006. CAGE: cap analysis of gene expression." Nature Methods 3 (3): 211.
- Root Phenotyping for Drought Tolerance: A Review, Wasaya A, Zhang X, Fang Q and Yan Z. 2018. Agronomy 8, 241; doi: 10.3390/agronomy8110241
- Sadhukhan A and Sahoo L and Panda S. 2012. Chemical Genomics in Plant Biology. Indian Journal of Biochemistry and Biophysics. 49. 143-154.
- Shan Q, Wang Y, Li J, Yi Z, Chen K, Liang Z, Zhang K et al. 2013. Targeted genome modification of crop plants using a CRISPR-Cas system. Nature Biotechnology 31 (8): 686.
- Šimura J, Antoniadi J, Tarkowská D, Strnad M, Ljung K and Novák O. 2018. Plant hormonomics: Multiple phytohormone profiling by targeted metabolomics. Plant Physiology 177 (2): 476-489.
- Sinclair TR and Muchow RC. 1999. Radiation use efficiency. In Advances in Agronomy 65: 215-265. Academic Press, 1999.
- van Maarschalkerweerd M and Søren H. 2015. Recent developments in fast spectroscopy for plant mineral analysis. Frontiers in Plant Science 6: 169.
- Watson A, Ghosh S, Matthew JW, Cuddy WS, Simmonds J, Rey MD et al. 2018. Speed breeding is a powerful tool to accelerate crop research and breeding. Nature Plants 4 (1): 23.
- Watson MC. 2018. Fogponic plant growth system. U.S. Patent Application 15/974,356 filed December 27.
- Yopp John H, Louis Htin Aung, and George L. Steffens (eds). 1986. Bioassays and other special techniques for plant hormones and plant growth regulators." Plant Growth Regulator Society of America.
- Zhang Y, Menghong D and Zonghui Y. 2018. Methods for the detection of reactive oxygen species. Analytical Methods 10 (38): 4625-4638.

CPH 504	Physiology of Woody Plants	2+0
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### Theory

- Unit I: Introduction, Tree physiology. Growth, phases of growth, growth curve, factors affecting growth.- Wood formation.
- Unit II : Plant cell as a structural and functional unit. Organization of cells and tissues, morphogenesis.
- Unit III: Structure of leaves, stem wood, bark and roots in trees. Functions and process in plant growth and development.

- Unit IV: Photosynthesis, structure of photosynthetic tissues and organs, enzyme, energetics and factors influencing photosynthesis. Photorespiration, its mechanisms and significance, factors affecting photorespiration.
- Unit V: Respiration, mechanisms, enzymes, energetics and factors influencing respiration. Respiratory quotient.
- Unit VI: Water relations of trees, absorption, ascent of sap. Translocation of solutes, phloem loading and phloem transport. Transpiration, mechanisms and factors influencing, regulating transpiration, antitranspirants.
- Unit VII: Mineral nutrition. Mineral salt absorption and translocation, deficiency and toxicity of mineral nutrients. Diagnosis of mineral deficiency.
- Unit VIII : The enzymes, nomenclature and classification, structure and compositioned. Mode of action. Phytohormones, auxins, GA, cytokinins, ABA, ethlynene. Biosynthesis and biochemical activity of plant hormones. Synthetic plant growth regulators. Growth retardants.
- Unit IX : Nitrogen fixing trees, Nitrogen metabolism. N2 fixation, physical and biological. Nitrogen assimilation, Amino acid and protein synthesis.
- Unit X: Fat metabolism. Carbohydrate metabolism.

Dr. Stephen G. Pallardy, 2008, Physiology of Woody Plants, Third Edition, School of Natural Resources University of Missouri Columbia, Missouri

### **ENVIRONMENTAL SCIENCE**

SL NO	COURSE NO	COURSE TITLE	CREDIT HOURS
01	EVS 501	Biodiversity and Conservation	1+1
02	EVS 502	Remote Sensing and GIS Appplication in	1+1
		Biodiversity Conservation	
03	EVS 503	Global Climate Change and Environment	2+0

EVS 501Biodiversity and Conservation1+1
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#### Theory

Elements of Biodiversity – Measuring biodiversity – Species abundance – species diversity – number and difference – habitat distribution – Biodiversity through time – the fossil record – history of biodiversity – diversification – extinction –. Mapping biodiversity – Species –Area relationships – Local regional diversity relationships – Extremes of high and low diversity – Gradients in biodiversity – latitudinal, altitudinal and depth gradients in biodiversity – Importance of biodiversity – Use value. Maintaining biodiversity – the scale of human enterprise – The Convention on Biological Diversity. Why conservation – Objectives and general measures for conservation and sustainable use –In –situ and Ex –situ Conservation Tropical forests and their conservation – Deforestation –The pressure on wildlife – conservation of species – species extinction – Genetic diversity in rare species – Conservation areas – Conservation of the biosphere – Special projects for endangered species – Man and Biosphere programmes – Viable conservation.

### **Practicals**

Species abundance – species richness – interrelationships. Populations – growth regulation and interaction. Habitat distribution – Natural selection – Genetic variability in natural populations –Conservation –tropical forests –wildlife ecosystems – Endangered species –viable conservation.

### **Suggested References**

David L. Hawksworth, 2018, Biodiversity and Conservation

EVS 502	Remote Sensing and GIS Appplication in Biodiversity Conservation	1+1
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### Theory

Introduction to remote sensing, electromagnetic spectrum– physics of remote sensing, effects of atmosphere, spectral reflections of earth objects. GPS– introduction basic principles, definition of map, computer assisted cartography, hardware requirements, types of data. Spatial and non–spatial data. Raster and Vector data conversion, Geographic information system analysis and modeling, digital counter modeling, errors, elimination. GIS software packages, capabilities, creating base maps, raster and vector

conversions. Digitizing- linking data files, tools for mapping and GIS. Use of GIS in policy and planning. Various platforms for data acquisitions, aerial photography, satellite sensors; optical, thermal and microwave. Different types of data products and their characteristics. Satellite data acquisitions. Storage and retrieval, visual interpretations, digital image processing.

## Practicals

Introduction to software's used in remote sensing and GIS Study of land use planning and equipments used in aerial photography. Study of scales of serial photography and interpretation. Case studies on application of satellite imageries and GIS.

## **Suggested References**

www.biodiversity.org, www.remote-sensing-biodiversity.org www.themightyearth.com www.biodiversitya-z.org

EVS 503	Global Climate Change and Environment	2+0
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### Theory

Issues on global climate change, Climate change and biodiversity, IPCC assessment on climate change and International conventions, El nino effect, Climatic fluctuations over India, climate change and global desertification process, Ongoing efforts on climate change research. Greenhouse gases – CO2, CH4, NOx, CFCs etc. Greenhouse gases in atmosphere, global warming potential, source – sink ratios and atmospheric loading rates etc.. Mitigation options of greenhouse gases. CO2 enrichment studies and plant response, O3 depletion and CFC's , climate change mitigation in polar regions. Causes and control measures, Impact on different ecosystem. Role of mathematical models in predicting climate change and its impact on productivity and soil fertility.

### **Suggested References**

Dr Chiradeep Basak, 2021, Thomson Reuters Global Climate Change and Environmental Laws in India

## FOOD SCIENCE AND NUTRITION

SL NO	COURSE NO	COURSE TITLE	CREDIT HOURS
01	FSN 501	Principles of Nutrition	3+0
02	FSN 502	Food Analysis	1+2

FSN 501Principles of Nutrition3+0
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#### Theory

Functions, sources, requirements, digestion and absorption of carbohydrates; definition, composition, classification, functions and role of dietary fibre in various physiological disorders. Basis of requirement, functions, sources, digestion and absorption of protein; Methods of assessing protein quality. Basis of requirement, functions, sources, digestion, absorption and deficiency disorders of lipids; essential fatty acids. Requirements, functions, sources, deficiencies and toxicities, fat and water soluble vitamins. Requirement, functions, sources, deficiency, toxicity and factors affecting absorption and utilization of macro and micro minerals. Water balance; acid and base balance.

## **Suggested References**

Bamji MS, Rao NP and Reddy V. 2003. Textbook of Human Nutrition. 2nd Edition, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

- Berdanier CD and Zempleni J. 2009. Advanced Nutrition: Macronutrients, Micronutrients and Metabolism. CRC Press, New York.
- Eastwood MA. 1997. Principles of Human Nutrition. London; Chapman & Hall.

Rosalind S Gibson. 2005. Principles of Nutritional Assessment. 2ndEdition, Oxford University Press Inc.

### Theory

Familiarization to terms and calculations used in preparation of various standard solutions. Sample and sampling techniques. Principles, techniques and applications of colorimetric, spectrophotometer and atomic absorption spectrophotometer. Principles, techniques and applications of spectrophotometer, fluorimetry, flame photometry and electrophoresis. Principles techniques and application of chromatography (paper chromatography, TLC,GLC, HPLC). Introduction to animal assay.

### **Practicals**

Handling of equipment and instruments; preparation of samples, solutions and buffers; quantitative estimation of proximate principles, minerals and vitamins by use of colorimetry, flame photometry, UV, spectrophotometer; chromatography, atomic absorption spectrophotometer and photofluorometry, analysis of antinutritional factors; estimation of protein and starch digestibility; fractionation of protein; food adulteration.

- AOAC. 1995. Association of Official Analytical Chemists. Washington, DC.
- Gruenwedels DW and Whitakor JR. 1984. FoodAnalysis: Principles and Techniques. Vols. I-VIII. Marcel Dekker.
- AOAC International. 2016. AOAC Official Methods of Analysis. 20th Edition, Association of Official Analytical Chemists. Washington DC.
- Dennis D Miller. 1998. Food Chemistry: A Laboratory Manual. John Wiley and Sons Indianapolis.
- Joslyn MA. 1970. Methods in Food Analysis: Physical, Chemical and Instrumental Methods of Analysis. Academic Press.
- Kalia M. 2002. Food Analysis and Quality Control. Kalyani Publishers, New Delhi.
- Neilsen SS. 2010. Food Analysis. 4th Ed., ISBN 978-1-4419-1478-1 Springer Science+ Business Media, LLC, USA.
- Neilsen SS. 2002. Introduction to Chemical Analysis of Foods. 1st Ed., J S Offset Printers, Delhi.
- Raghuramulu N, Mahavan and Kalyanasundaram SK. 2003. A Manual of Laboratory Techniques. 2nd Edition, NIN Press, Hyderabad.
- Sadasivam A and Manickam A. 2004. Biochemical Methods. 2nd Edition, New Age International Publishers, New Delhi.
- Sawhney SK and Singh R. 2000. Introductory PracticalsBiochemistry. Narosa Publishing House, New Delhi.
- Veerakumar L. 2006. Bio-instrumentation. MIP Publishers. Chennai. Pomeranz Y and Molean CE. 1977. Food Analysis Theory and Practice. AVI Publ.
- Wood R, Foster L, Damand A and Key P. 2004. Analytical Methods for Food Additives. CRC Press, London.
- https://www.fssai.gov.in
- http://www.fda.gov/food/default.htm

## BIOCHEMISTRY

SL NO	COURSE NO	<b>COURSE TITLE</b>	CREDIT HOURS
01	BCM 501	Basic Biochemistry	2+1
02	BCM 502	Biochemical Techniques	1+2

BCM 501	Basic Biochemistry	2+1

#### Theory

Scope and importance of biochemistry in agriculture;Fundamental principles governing life; Structure of water; Acid–base concept and buffers; pH; Hydrogen bonding; Hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers. Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids. Structure and biological functions of vitamins; Enzymes: classification and mechanism of action, regulation, factors affecting enzyme action. Hormones: animals, plants and insects.Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics. Metabolism of carbohydrates, photosynthesis and respiration, oxidative phosphorylation, lipids, proteins and nucleic acids. DNA replication, transcription and translation; recombinant DNA technology.

#### **Practicals**

Preparation of standard and buffer solutions, Extraction and estimation of sugars, Amino acids, Estimation of Proteins by Lowry's method, Estimation of DNA and RNA by diphenylamine and orcinol methods. Estimation of Ascorbic acid. Separation of biomolecules by TLC and Paper chromatography.

### **Suggested References**

- 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. 5<sup>th</sup> 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.

BCM 502	Biochemical Techniques	1+2
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#### Theory

Chromatographic and electrophoretic methods of separation, Principles and applications of Paper, Thin layer & HPTLC, Gas, Gas-liquid and Liquid chromatography, HPLC and

FPLC; Paper and gel electrophoresis, Different variants of polyacrylamide gel electrophoresis (PAGE) like native and SDS–PAGE, 2D–PAGE, capillary electrophoresis. Spectrophotometry: Principles and applications; UV–Visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X–Ray spectroscopy. Hydrodyanmic methods of separation of biomolecules such as viscosity and sedimentation– their principles, variants and applications. Tracer techniques in biology: Concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of á, â and ã emitters, scintillation counters,  $\tilde{a}$ – ray spectrometers, autoradiography, applications of radioactive tracers in biology, principles and applications of phosphor imager.

## Practicals

Determination of absorption maxima of some important chemicals from their absorption spectra, estimation of biomolecules using spectrophotometer, Separation of carbohydrates and amino acids by paper chromatography, Separation of lipids by thin layer and column chromatography, Separation of proteins by ion exchange and gel filtration chromatography, Electrophoretic techniques to separate proteins and nucleic acids, Centrifugation– Cell fractionation; Application of GLC, HPLC and FPLC in separation of biomolecules, Use of radioisotopes in metabolic studies.

## **Suggested References**

- 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 PracticalsBiochemistry. 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

## FORESTRY (PLANTATION TECHNOLOGY)

SL NO	COURSE NO	COURSE TITLE	CREDIT HOURS
01	FOR 501	Forest Ecology and Biodiversity Conservation	2+1
02	FOR 502	Tree Improvement	1+1
03	FOR 503	Energy Plantations and Bio-fuels	1+1

EOD 501	Forest Foology and Diadivarity Concernation	2.1
FUK 501	Forest Ecology and Blourversity Conservation	<u>4</u> +1

### Theory

Advanced topics in forest ecology including forest population, forest community dynamics, forest community structure and analysis, forest productivity on a global scale, ecology of forest landscapes spatial heterogeneity; Hierarchy issues in ecology. Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserve). Global warming and forests. Green House Effect and its consequences. Ozone depletion. Conservation laws and acts. Forest genetics resources of India: timber and non timber species. Survey exploration and sampling strategies. Biological diversity: concept, types, distribution, magnitude and Benefits. Its significance to sustainable use. Inventorying, mapping and monitoring biodiversity. Loss of Biodiversity: Patterns, Causes and Mitigation. Global Climate change and forests. Green House Effect and its consequences. Ozone depletion. Documentation and evaluation of forests genetic resources (FGR), in situ and ex situ conservation of gene resources. Biological diversity and its significance to sustainable use. Handling and storage of FGR. Intellectual property rights. Quarantine laws and FGR exchange. Principles of Conservation biology. Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserve). IUCN categories and examples. Conservation laws and acts. Survey exploration and sampling strategies.

## Practicals

Study of forest community structure and its successional status, Estimation of productivity of forest ecosystem, Trip to different regions of the state to study forest vegetation, Collection and preservation of specimen, Methods of vegetation analysis, Measurement of biomass and productivity, Quantification of litter production and decomposition, Visit to national parks, wildlife sanctuaries, botanical gardens and arboretum.

## Suggested References

- Avery TE and Burkharts H. 2001. *Forest Measurements*. McGraw-Hill Education. Barnes BV, Zak DR, Denton SR and Spurrs SH. 1998. *Forest Ecology*. Wiley.
- Jha BC, Pandey BN, Jaiswal K, Katiha PK, Pandey PN and Sharma AP. 2012. Biodiversity: Issues Threats and Conservation. Narendra Publishing House, Delhi.

Kumar Biju. 2013. Biodiversity and Taxonomy. Narendra Publishing House, Delhi.

Larocque GR. 2016. Ecological Forest Management Handbook (Applied Ecology and Environmental Management). Taylor & Francis.

- Mahato B, Pandy BN, Singh LB, Panday PN and Singh RK. 2010. *Text Book of Environmental Pollution*. Narendra Publishing House, Delhi.
- Mikusiñski G, Roberge JM and Fuller R. 2018. *Ecology and Conservation of Forest Birds*(*Ecology, Biodiversity and Conservation*). Cambridge University Press.
- Pandey PN. 2009. Biodiversity and Environment Ecology. Narendra Publishing House, Delhi. Perry DA, Oren R and Hart SC. 2008. Forest Ecosystems. 2nd ed. Baltimore: Johns Hopkins University Press.
- Young RA and Giese RL. 2003. Introduction to Forest Ecosystem Science and Management.Wiley.

FOR 502	Tree Improvement	1+1
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### Theory

General concept of forest tree breeding, tree improvement and forest genetics. Reproduction in forest trees, dimorphism pollination mechanisms. Pollen dispersion distances, pollinators and their energetics. Attractants for pollinators. Pollen handling forced flowering for seed orchard manipulation. Pollination mechanisms. Variation in trees importance and its causes. Natural variation as a basis for tree improvement. Geographic variations - Ecotypes, clines, races and land races. Seed, seed formation, dispersal, storage, stratification and seed dormancy. Selective breeding methods- mass, family, within family, family plus within family. Plus tree selection for wood quality, disease resistance and agroforestry objectives. Selection strategies and choice of breeding methods and progress in selective breeding in forest trees. Indirect selection for biotic and abiotic stresses. Progeny and clone testing. Seed orchards - type, functions and importance. Estimating genetic parameters and genetic gain. Heterosis breeding: inbreeding and hybrid vigour. Manifestation and fixation of heterosis. Species and racial hybridization. Indian examples - teak, sal, shisham, eucalypts, acacias, pines and poplars. Polyploidy, aneuploidy and haploidy in soft and hard wood species. Induction of polyploidy. Hardy-weinberg law, null hypothesis, Wohlund's Principle. Biotechnology in tree improvement. Mutation breeding. Marker assisted selection and examples. Economics of tree breeding. Seed certification.

### Practicals

Floral biology, modes of reproduction and modes of pollination in forest trees. Estimating pollen viability. Controlled pollination and pollen handling. Manipulation of flowering through hormones. Identification of ecotypes, races, and land–races in natural forest. Visit to species, provenance and progeny trials. Selection of superior phenotypes. Marking of candidate trees, plus trees and elite trees. Visit to seed orchards. Comparison of parents and their putative hybrids. Induction of polyploidy through colchicine treatment. Practicals: Mateing designs in Forestry and progeny testing. Design and evaluation of tree improvement experiments.

## Suggested References

Dutta M and Saini GC. 2009. *Advances in Forestry Research in India*, Vol. XXX. Forest Tree Improvement and Seed Technology. International Book Distributors.

Finkeldey R and Hattemer HH. 2006. Tropical Forest Genetics. Springer.

Mandal AK and Gibson GL. (Eds). 1997. *Forest Genetics and Tree Breeding*. CBS. Sedgley M and Griffin AR. 1989. *Sexual Reproduction of Tree Crops*. Academic Press.

Surendran C, Sehgal RN and Paramathma M. 2003. *Text Book of Forest Tree Breeding*. ICAR. White TL, Adams WT and Neale DB. 2007. *Forest Genetics*. CABI, UK.

Wright JW. 1976. Introduction to Forest Genetics. Academic Press.Zobel BJ and Talbert J. 1984. Applied Forest Tree Improvement. John Wiley and Sons.

Ramawat KG, Merillon JM and Ahuja MR. 2014. *Tree Biotechnology*. CRC Press. Schnell RJ and Pridarshan PM. 2012. *Genomics of Tree Crops*, Springer.

White TL, Adams WT and Neale DB. 2007. Forest Genetics. CABI.

FOR 503	Energy Plantations and Bio-fuels	1+1

### Theory

Introduction and advantages of energy plantations. Energy and biomass consumption patterns in India. Environmental impacts of biomass energy. Assessment of bio-energy programmes in India. Power generation from energy plantation, producer gas. High Density Energy Plantations (HDEP). Land and biomass availability for sustainable bio energy. Impact of energy efficiency in power sector. Need for research and development on environment friendly and socio economical relevant technologies. Energy from plants- problems and prospects. Petro-crops. Criteria for evaluation of different species for energy plantation. Recent energy technologies in the product of bio-fuels.

### **Practicals**

Identification of important fuel woods and petro-crops. Study on different bio fuels used in India. Determination of calorific value, moisture and ash content in biomass Study of energy consumption pattern in rural and urban areas through survey. Visit to nearby Bio-energy units.

## **Suggested References**

David, P., 2012, Global economic and environmental aspects of Biofuels. CRC Press. Grammelis, P., 2011, Solid Biofuels for Energy. Springer Pub.

Luna, R. K., 1989, Plantation Forestry in India. International Book Distributors.

Shibu, J. and Bhaskar, T., 2015, Biomass and Biofuels: Advanced Biorefinerties for Sustainable Production and Distribution CRC Press.

Sunggyu, L. and Shah, Y. T., 2012, Biofuels and Bioenergy: Processes and Technologies, CRC Press.

## HORTICULTURAL STATISTICS

SL NO	COURSE NO	COURSE TITLE	CREDIT HOURS
01	HST 501	Statistical Methods for Applied Sciences	1+1
02	HST 502	Experimental Designs	2+1

HST 501	Statistical Methods for Applied Sciences	1+1
1151 301	Statistical Methods for Applied Sciences	1+1

### Theory

Review of Probability, Discrete and continuous probability distributions: Binomial, Poisson, Normal distribution, distributions and their applications and fitting of distributions. Sampling Distribution – means and proportions, Std. error. Introduction to theory of estimation and confidence–intervals. Testing of Hypothesis, type I and type–II errors. Tests of significance based on Normal, student F distributions and chi–square. Large sample theory. Correlation and regression. Simple linear regression model, estimation of parameters Predicted values. Test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Analysis of variance technique. One way analysis of variance. Two way analysis with one and multiple observations.

Practicals Solving problems on above topics

## **Suggested Referecnces:**

- Goon A.M, Gupta M.K and Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.
- Goon A.M, Gupta M.K. and Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.
- Hoel P.G. 1971. Introduction to Mathematical Statistics. John Wiley.
- Hogg R.V and Craig T.T. 1978. Introduction to Mathematical Statistics. Macmillan.

Morrison D.F. 1976. Multivariate Statistical Methods. McGraw Hill.

- Hogg RV, McKean JW, Craig AT. 2012. Introduction to Mathematical Statistics 7th Edition.
- Siegel S, Johan N & Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley.
- Anderson TW. 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.

### 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.

## Practicals

- 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 References**

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

- Dean AM and Voss D. 1999. Design and Analysis of Experiments. Springer.
- Montgomery DC. 2012. Design and Analysis of Experiments, 8th Ed. John Wiley.

Federer WT. 1985. Experimental Designs. MacMillan.

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

- Nigam AK and Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.
- Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley.

www.drs.icar.gov.in.

Sl.No.	Course	Course Title	Credit
	No.		Hours
1	SST 501	Seed Production Principles and Techniques in	2+1
		Vegetable Crops	
2	SST 502	Seed Production Techniques in Fruits, Flowers,	2+1
		Spices, Plantation and Medicinal Crops	
3	SST 503	Seed Legislation and Certification	2+1
4	SST 504	Post Harvest Handling and Storage of Seeds	2+1
5	SST 505	Seed Quality Testing and Enhancement	1+1
6	SST 506	Seed Industry and Marketing Management	1+1
7	SST 507	Seed Health Testing and Management	1+1

## SEED SCIENCE AND TECHNOLOGY

SST 501 Seed Production Principles and Techniques in Vegetable Crops 2+1

#### Theory

- Unit I : Importance and present status of vegetable seed industry factors influencing vegetable seed production; varietal and hybrid seed production techniques in major solanaceous vegetable crops tomato, brinjal, chilli; malvaceous vegetable crop bhendi.
- Unit II : Varietal and hybrid seed production techniques in important cucurbitaceous vegetables gourds and melons, cole crops cauliflower, cabbage, knol-khol, root vegetables carrot, , radish and other temperate/ hilly vegetable crops.
- Unit III :Varietal seed production techniques in major leguminous vegetables garden peas, dolichos and beans; seed production techniques in leafy vegetables – amaranthus, palak, spinach, and lettuce.
- Unit IV :Seed production techniques in tuber crops potato, sweet potato, colocasia, tapioca and yam, seed-plot technique in potato – true potato seed (TPS) production techniques – seed production techniques in bulb crops – onion, garlic.
- Unit V :Vegetative and clonal multiplication methods, merits and demerits; clonal multiplication potato, sweet potato, colocasia, tapioca and yam.

#### Practicals

- Studying floral biology of other vegetable crops;
- Identification of vegetable seeds;
- Studies on internal structure of vegetable seeds
- Study on sowing and nursery management;
- Study on transplanting and age of seedling on crop establishment;
- Studying Studies on floral structure and floral biology of solanceous, malvaceous
- Studies on floral structure and floral biology of cucurbits and root vegetables
- Planting methods and planning for vegetable hybrid seed production
- Selfing and crossing techniques in vegetable seed production
- Modification of sex ratio in cucurbits;
- Practicing emasculation and pollination methods in tomato, brinjal, chilli and okra
- Practicing roguing operations identification of off-types selfed fruits;

- Special agronomic practices for higher fruit and seed setting
- Study on physiological and havesting maturity indices
- Practicing seed extraction methods wet methods tomato, brinjal, other cucurbitaceous fruits;
- Seed extraction dry methods chillies, bhendi, cucurbitaceous;
- Seed Viability test
- Visit to seed production fields;
- Visit to private seed industry, grower, producer and certification agency;
- Planning and economics of varietal seed production;
- Planning and economics of hybrid seed production.

- Agarwal RL. 2012. Seed Technology. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.
- Chadha KL. 1995. Advances in Horticulture. Volume 1 to 13. Malhothra Publishing House, New Delhi.
- George RAT. 1985. Vegetable Seed Production. Lonhman Inc., New York.
- Hebblethwaite PD. 1980. Seed Production. Butterworth Heinemann Ltd, London, UK. Kulkarni GN. 2011. Principles of Seed Technology. Kalyani Publishers, New Delhi.
- Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
- McDonald MB and Copeland L. 1998. Seed Production: Principles and Practices. CBS Publishers, New Delhi.
- Sen S and Ghosh N. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi. Singhal NC. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.
- Vanangamudi K, Natarajan N, Srimathi P, Natarajan K, Saravanan T, Bhaskaran M, Bharathi A, Natesan P and Malarkodi K. 2006. Advances in Seed Science and Technology. Vol. 2. Quality Seed Production in Vegetables. Agro bios, Jodhpur.

Suggested e-books <a href="https://www.springer.com/in/book/9780792373223">https://www.springer.com/in/book/9780792373223</a>

http://203.64.245.61/fulltext-pdf/EB/1900-2000/eb0021.pdf

http://www.worldseed.org/wp-content/uploads/2017/01/Seed-Production-Good-practice-

<u>10.01.17-final.pdf</u>

 $\frac{https://trove.nla.gov.au/work/6862691?q\&sort=holdings+desc\&-=1541066209257\&versionId=45008917+251246346$ 

## Suggested websites

https://agriinfo.in/botany/18/

http://agritech.tnau.ac.in/seed\_certification/seedtech\_index.html

http://www.yspuniversity.ac.in/vgc/caft/Compendium2017-18.pdf

https://www.hort.vt.edu/Welbaum/seedproduction/Principles5.html

http://www.agrimoon.com/wp-content/uploads/Seed-Production-of-Vegetable.pdf

http://www.ciks.org/downloads/seeds/4.%20Seed%20Production%20Techniques%20for% 20Vegetables.pdf

## Theory

- Unit I : Scope for seed production in fruits, flowers, spices, plantation and medicinal crops; factors influencing seed production and quality; propagation methods seed and clonal propagation; seed and seedling standards; propagation and seed production techniques in major tropical, sub-tropical and temperate fruit crops; seed orchards
- seed collection, extraction processing and storage techniques.
- Unit II : Seed production techniques in commercially important annual flower crops- marigold, petunia, daisy, china aster, zenia, crossandra, gellardia, salvia, sunflower- nursery management, clonal propagation, gladiolous, tube rose, gerbera, carnation planting, seed crop management, post-harvest seed handling and storage techniques.
- Unit III :Seed production techniques in commercially important seed spices coriander, fenugreek, cumin, fennel, ajwain and other spices ginger, turmeric– nursery management, sowing, seed crop management and post-harvest seed handling and storage techniques.
- Unit IV : Seed production in commercially important plantation crops- coconut, arecanut, nut mug, cardamom, black pepper mother tree selection criteria nursery management, elite seedling production, planting, plantation management, post-harvest handling and storage techniques.
- **Unit V :** Methods of quality seed production in commercially important medicinal plants- basil, ocimum, black jeera, senna, nursery management, sowing, seed crop management, post-harvest handling and storage methods.

### Practicals

- Study on the floral structure and floral biology and pollination mechanism
- Identification of seeds of fruits, flowers, spices, plantation and medicinal crops;
- Selection of mother plants and trees phenotypic characters and genotypic characters;
- Study on different types of clonal and vegetative propagules;
- Seed and clonal standards of vegetatively propagating crops;
- Seed dormancy and dormancy breaking treatments
- Study on selection of planting materials and sowing methods;
- Nursery management practices for elite seedling production;
- Seed extraction methods wet method and dry method;
- Post harvest seed handling seed grading, upgrading techniques
- Study of seed storage techniques;
- Seed germination enhancement techniques in fruits, spices and plantation crops;
- Seed germination enhancement techniques in flowers and medicinal crops;
- Planning for seed production economics of seed production in flower crops;
- Visit to mother tree orchard;
- Visit to plantation and orchard.

- Chadha KL. 1995. *Advances in Horticulture*. (Volume 1 to 13). Malhotra Publishing House, New Delhi.
- Hartman HT and Kester DE. 2000. *Plant Propagation: Principles and Practices*. Prentice Hall, New Jersey, USA.
- Singh SP. 2001. Seed Production of Commercial Vegetables. Agrotech, New Delhi.
- Vanangamudi K and Natarajan K. 2008. Advances in Seed Science and Technology. Quality Seed Production in Spices, Plantation, Medicinal and Aromatic crops (Vol. 5). Agrobios. Jodhpur.
- Vanangamudi KM Prabu and Lakshmi S. 2012. Advances in Seed Science and Technology Vol.7. Flower Seed Production. Agrobios, Jodhpur.
- Suggested e-books
- http://www.worldseed.org/wpcontent/uploads/2017/01/Seed-Production-Good-practice-10.01.17- final.pdf

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4233836/

https://www.academia.edu/35629702/Hybrid\_Seed\_Production\_and\_Flowers

http://www.agrimoon.com/horticulture-icar-ecourse-pdf-books/

https://cbp.icar.gov.in/EBook.aspx

Suggested websites

www.cimap.res.in/english/index.php

www.dmapr.org.in/amprs.kau.in/basic-page/publications

http://ecoursesonline.iasri.res.in/course/view.php?id=153

http://ecoursesonline.iasri.res.in/course/view.php?id=612

http://www.celkau.in/Crops/Plantation%20Crops/Rubber/production.aspx

http://sbc.ucdavis.edu/Courses/Seed\_Production/

SST 503	Seed Legislation- and Certification	2+1
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### Theory

- Unit I : Genesis of seed Industry in India; seed quality control concept and objectives; regulatory mechanisms – Seed Act (1966) – Seed Rules (1968) – statutory bodies – Central Seed Committee – Central Seed Certification Board.
- Unit II : Seed Control Order (1983) New Policy on Seed Development (1988) Exim Policy – National Seed Policy (2002) – Plant Quarantine Act.
- Unit III :Introduction to WTO and IPR UPOV and its role OECD seed certification schemes
   PPV & FR Act (2001) and Rules (2003) Seed Bill (2004 and 2019): Seed certification system in SAARC countries, Europe, Canada, Australia and USA.
- Unit IV :Seed certification history and objectives; general and specific crop standards, field and seed standards; seed certification agency – role of certification agency/ department and seed certification officers, phases of seed certification; field inspection – counting procedures – liable for rejection (LFR) – downgrading and partial rejection – reporting.
- Unit V :Post-harvest inspection construction of seed lot number; seed sampling testing labeling, sealing and grant of certificate types and specifications for tags and labels; seed lot validity and revalidation; appellate authority, stop sale order, penalties records

and registers to be maintained by seed processing units and seed dealers – verification procedures, role of seed analyst and seed inspector in quality regulation.

## Practicals

- Preparation of sowing report varieties transplanted and direct sown crops and hybrids;
- Verification of sowing report seed certification procedures;
- Field inspection estimation of area and isolation distance, stages of inspection for varieties and hybrids procedures;
- Practicing field counting procedures methods for row planting, broadcasted varieties;
- Practicing field counting procedures direct sown and transplanted crops varieties;
- Study on field counting procedures hybrids planting design, planting ratio and block method and double count;
- Identification of contaminants genetic and physical contaminants, procedure to remove partials, pollen shedders and shedding tassels;
- Assessing and calculation of field standards for important crops;
- LFR, partial rejection and downgrading reasons, procedures and preparation of reports;
- Yield estimation single and multiple harvest crops;
- Post harvest inspection groundnut, cotton, pulses;
- Inspection and maintenance (licence and renewal) of records in processing unit float test, preparation of processing report and seed lot number construction;
- Visit to seed certification agency/ department;
- Visit to grow-out test field;
- Visit to seed retail shop procedures followed by Seed Inspector, verification of records and reporting;
- Procedure to issue tag, specification, bagging, tagging, labelling and sealing.

# **Suggested References**

Agarwal RL. 2012. Seed Technology. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi.

Anon. 2016. *Manual of Seed Certification Procedures*. Directorate of Seed Certification, Coimbatore, Tamil Nadu.

- Chakrabarthi SK. 2010. Seed Production and Quality Control. Kalyani Publishers, New Delhi.
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Tunwar NS and Singh SV. 2003. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, GOI, New Delhi.

http://cms.tn.gov.in/sites/default/files/documents/seed-certification-0.pdf http://odishaseedsportal.nic.in/SeedPortalData/Resource%20Material/INDI AN-MINIMUM-SEED-CERTIFICATION-STANDARDS.pdf https://www.india.gov.in/my-government/documents/e-books https://books.google.co.in/books/about/Principles\_of\_Seed\_Certification\_and\_ Tes.html?id=SQWHAAAACAAJ&redir\_esc=y https://dl.sciencesocieties.org/publications/books/tocs/cssaspecialpubl/theroleofseedce

SST 504	Post Harvest Handling and Storage of Seeds	2+1
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## Theory

- Unit I : Seed processing objectives and principles; processing sequence threshing, shelling, extraction methods; drying – principles and methods; seed cleaning, grading, upgrading – methods – machineries and equipment – scalper, precleaner, cleaner cum grader, specific gravity separator, indented cylinder, disc separator, spiral separator, velvet separator, magnetic separator, electronic colour sorter – working principles and functions.
- Unit II :seed processing elevators and conveyers processing plant specifications, design and layout; mechanical injury causes and detection management.
- Unit III :Seed treatment methods pre and mid storage seed treatments, seed treating formulations and equipments; packaging materials types bagging and labeling; seed blending principle and methods.
- Unit IV :Seed storage purpose and importance factors affecting storage, optimum condition for storage of different seeds; storage principles Harrington's thumb rule concepts and significance of moisture equilibrium maintenance of safe seed moisture physical, physiological, biochemical and molecular changes during seed storage storage behaviour of orthodox and recalcitrant seeds prediction of viability viability nomograph.
- Unit V :Methods of seed storage modified atmospheric storage ultra dry storage vacuum storage cryopreservation germplasm storage gene banks NBPGR, IPGRI and National seed storage laboratory; seed storage godown structure maintenance sanitation.

## **Practicals**

- Seed extraction wet and dry methods;
- Seed processing sequence for different crops;
- Design of processing plant equipments estimation of processing efficiency;
- Seed drying methods principle and methods;
- seed grading upgrading macheneries- specific gravity separator
- Seed packaging –packaging materials and storage conditions;
- Prediction of viability during storage viability nomograph and accelerated ageing test;
- Assessing physical changes during seed storage;
- Assessing physiological changes during seed storage;
- Assessing biochemical changes during seed storage;
- Storage behaviour of recalcitrant seeds;
- Pre-storage seed treatments film coating and pelleting
- seed blending

- Seed storage godown sanitation, fumigation visit to seed storage godown and cold storage unit.
- Visit to seed processing unit;

Barton LV. 1961. Seed Preservation and Longevity, (Vol. 1). Leonard Hill, London.

- Gregg BR, Law AG, Virdi SS and Balis JS. 1970. Seed Processing. Avion printers, New Delhi.
- Gupta D. 2009. *Seeds: their conservation principles and practices*. Sathish serial publishing house. New Delhi.
- Justice OL and Bass LN. 1978. *Principles and Practices of Seed Storage*. Agriculture Hand Book No. 506, Castle House Publication Ltd., Washington.
- Kulkarni GN. 2011. Principles of Seed Technology. Kalyani Publishers, New Delhi.
- Maiti RK, Sarkar NC and Singh VP. 2006. *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
- Padmavathi S, Prakash M, Ezhil Kumar S, Sathiyanarayanan G and Kamaraj A. 2012. *A Text book of Seed Science and Technology*, New India Publishing Agency, New Delhi.
- Sen S and Ghosh N. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi. Singhal NC. 2010. Seed Science and Technology. Kalyani Publishers, New Delhi.

Suggested e-books

http://dfsc.dk/pdf/Handbook/chapter8\_internet.pdf

https://naldc.nal.usda.gov/download/CAT87208646/PDF

<u>https://www.springer.com/in/book/9780792373223</u> <u>http://203.64.245.61/fulltext-</u>

pdf/EB/1900-2000/eb0021.pdf

https://www.kopykitab.com/ebooks/2016/05/6997/sample/sample\_6997.pdf https://trove.nla.gov.au/work/6862691?q&sort=holdings+desc&-=1541066209257 &versionId= 45008917+251246346

http://www.worldseed.org/wp-content/uploads/2017/01/Seed-Production-Good-

practice-10.01.17- final.pdf

Suggested websites

http://www.fao.org/3/a-ah803e.pdf agritech.tnau.ac.in/seed\_certification/seedtech\_index.html http://ecoursesonline.iasri.res.in/mod/page/view.php?id=17806 http://www.bcseeds.org/wpcontent/uploads/2015/01/Seed-Processing-2015-update.pdf

https://www.carolinafarmstewards.org/wpcontent/uploads/2012/05/Seed Processingand StorageVer\_1pt3.pdf

## SST 505Seed Quality Testing and Enhancement1+1

### Theory

- Unit I : Seed testing history and development; seed testing in India; ISTA and its role in seed testing; seed lot and size, types of seed and size, samples sampling intensity and methods, sampling devices, receipt and registration of submitted samples in the laboratory and sub sampling; purity analysis components and procedure determination of other distinguishable varieties (ODV) and test weight determination application of heterogeneity test method of testing coated and pelleted seeds; seed moisture estimation principles and methods, application of tolerances.
- Unit II :Seed germination test requirements, media and methods seedling evaluation, tolerance and reporting results; viability test (TZ test) principle, procedure and evaluation; vigour tests concept of seed vigour and vigour test types of vigour tests direct and indirect tests physical, physiological and biochemical tests principles and methods; seed health test principles and methods.
- Unit III :Genetic purity assessment laboratory methods physical, chemical, biochemical and molecular tests – growth chamber and field testing (Grow Out Test) methods; testing of GM seeds; storage of guard sample – referral test; application of tolerance in seed testing; advanced non destructive techniques of seed quality analysis – soft x-ray imaging – hyper spectral imaging, thermal imaging – spectroscopy – e-nose and machine vision techniques.
- Unit IV :Seed quality enhancement techniques history and development; classification physical, physiological and protective seed treatments special seed treatments; physical seed treatment liquid floatation, specific gravity separation, irradiation, electric and electro-magnetic seed treatments principles and methods seed pelleting and coating principles, purpose and methods.
- Unit V :Physiological seed enhancement treatments seed infusion, seed priming principles and methods physiological, biochemical and molecular mechanisms; pre-germination and fluid drilling techniques; biological seed treatments microbial inoculation; organic seed treatment integrated seed treatment concept and methods of designer seed.

### **Practicals**

- Seed testing laboratory requirements and legal system
- Seed sampling- seed lot number, registration, samplers and dividing methods;
- Determination of seed test weight and heterogeneity test;
- Physical purity analysis components, procedure, reporting results;
- Seed moisture estimation methods and equipments;
- seed germination test and seedling evaluation;
- Conduct of quick viability (tetrazolium) test and evaluation;
- Conduct of vigour tests direct, indirect test and special tests;
- Genetic purity assessment laboratory and conventional methods image analysis for seed quality;
- Conducting different seed health tests to identify bacteria, fungi and storage pests;
- Seed enhancement techniques practicing physical treatments and water floatation techniques;

- Seed coating and pelleting uses of adhesives and filler materials;
- Pre-sowing treatments- seed priming hydro, halo and bio-priming-microbial composition solid matrix priming;
- Practicing seed infusion and microbial inoculation treatments;
- Practicing pre-germination technique;
- Studying integrated seed treatment/ designer seed treatment.
- Visit to seed testing laboratory;

Agrawal PK. 1993. Hand book of Seed Testing. Ministry of Agriculture, GOI, New Delhi

- Agrawal RL. 1997. Seed Technology. Oxford & IBH.
- Agrawal PK and Dadlani M. 1992. Techniques in Seed Science and Technology. 2nd Ed. South Asian Publications.
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- International Seed Testing Association. 2018. Handbook on Seedling Evaluation, 4th Edition, Published by ISTA, Zurichstr, Switzerland.
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- Vasudevan SN, Doddagowder SR, Rakesh CM and Patil SB. 2013. Seed Testing and Quality
- Control. Agrotech Publications, Udaipur, Rajasthan.

Suggested e-books

http://odishaseedsportal.nic.in/SeedPortalData/Resource%20Material/INDIAN MINIMUM SEED CERTIFICATION STANDARDS.pdf.

www.kopykitab.com/Seed-Testing-and-Quality-Control-by-Vasudevan-SN https://www.jstor.org/stable/10.14321/j.ctt7zt51m

https://www.jstor.org/stable/10.14521/j.ctt/2t5111

https://link.springer.com/chapter/10.1007/978-1-4615-1619-4\_13

https://www.researchgate.net/publication/269694458\_QUALITY\_SEED\_

PRODUCTION\_ITS\_TESTING\_AND\_CERTIFICATION\_STANDARD

https://www.seedtest.org/upload/cms/user/ISTAMethodValidationforSeed Testing-V1.01.pdf

https://www.intechopen.com/books/new-challenges-in-seed-biology-basic-and-

translational-research-driving-seed-technology/recent-advances-in-seedenhancements

Suggested websites

http://agritech.tnau.ac.in/seed/Seed\_seedtesting.html

https://core.ac.uk/download/pdf/85210907.pdf https://www.betterseed.org/resources/seed-testing-accreditation-schemes/ http://sbc.ucdavis.edu/About\_US/Seed\_Biotechnologies/Seed\_Enhancemen t/ https://www.seedtest.org/en/international-rules-for-seed-testing-content-1-1083. html

SST 506	Seed Industry and Marketing Management	1+1

### Theory

- Unit I : Introduction to seed industry genesis, growth and structure of seed industry mission and objectives present status of Indian and global seed industry role of seed industry in Indian agriculture; government initiatives seed hubs, seed villages and community seed production system.
- Unit II :Seed industry organization set up and functions public, private, MNC's, seed corporations; structure of small, medium and large seed industries, components of seed industry public private partnership custom seed production risk management human resource infrastructure processing unit storage go down.
- Unit III :Seed production and distribution systems in state and central government; seed village concept- seed supply chain systems seed production and distribution planning, SMR- SRR- organization and coordination, staffing, assembling of resources; cost of seed production overhead charges.
- Unit IV :Seed marketing definition importance role of marketing; type of markets domestic and global market problems and perspectives; marketing policies seed marketing schemes marketing channels, responsibilities of dealers marketing mix.
- Unit V :Seed demand forecasting purpose methods and techniques; indenting and seed dispatch procedures and forms seed store records maintenance missing link in seed supply chain; market intelligence SWOT analysis; seed cost analysis; seed pricing policy components of seed pricing factors local market rate (LMR) fixation of procurement and sale price of seed.

# Practicals

- Data collection on status of Indian and global seed industry;
- Assessing the factors influencing farmers preference and assessment of seed demand and supply;
- Planning for establishment of small, medium and large seed industry;
- Planning for establishment of seed production and processing unit;
- Economics of seed production varieties and hybrids;
- Seed pricings and cost analysis;
- Exercise on fixing seed procurement and sale price;
- Study of marketing channels domestic and international;
- Maintenance of carryover seeds Assessing risk factors in seed industry and their management;
- Survey and interaction with seed dealers and distributors;
- Case studies and SWOT analysis;
- Custom seed production, contract farming and procurement procedures;
- Planning and preparation of project proposal for setup of a seed industry;
- Visit to state seed corporations;
- Visit to MNCs and expert discussion;

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Broadway AC and Broadway A. 2003. A Text Book of Agri-business Management.
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Kugbei S. 2008. Seed Economics. Scientific Publishers, Jodhpur, Rajasthan.
Sharma P. 2008. Marketing of Seeds, Green-Tech Book Publishers, New Delhi.
Singh G and Asokan SR. 1991. Seed Industry in India: A Management Perspective Oxford & IBH Publishing Co Pvt. Ltd., New Delhi.

Singh S. 2004. Rural Marketing – Focus on agricultural Inputs. Vikas Publishing House.

# Suggested e-books

https://link.springer.com/chapter/10.1007/978-1-4615-1783-2-15 http://www.fao.org/3/V4450E/V4450E00.htm https://books.google.co.in/books?id=vPVIBos4WkYC http://download.nos.org/srsec319new/319EL19.pdf https://isengewant.de/Marketing-of-Seeds-By-Premjit-Sharma.pdf https://www.kopykitab.com/A-Handbook-of-Seed-Processing-and-Marketing-by-Gaur-SC

## Suggested websites

www.gov.mb.ca www.agricoop.nic.in

www.agri.nic.in

https://sathguru.com/seed/

http://www.fao.org/3/V4450E/V4450E03.htm

https://www.seednet.gov.in/smis/SMIS-User%20Manual.pdf

https://www.icrisat.org/seed-systems-models-lessons-learned/

https://www.bookdepository.com/Seed-Industry-India-Gurdev-Singh/

# SST 507Seed Health Testing and Management1+1

#### Theory

- Unit I : History and economic importance of seed health in seed industry and plant quarantine important seed borne and seed transmitted pathogens –designated diseases– role of microorganisms in seed quality deterioration storage and field fungi effect of storage fungi on seeds factors influencing storage fungi and management.
- Unit II :Transmission of pathogens mode and mechanism seed certification standards; mycotoxins – types and its impact on plant, animal and human health; seed health testing methods – direct examination, incubation, serological and molecular methods.
- Unit III : Production of disease free seeds in horticultural crops; management of seed borne pathogens – plant quarantine – Indian system and networking, post- entry quarantine and international systems – Pest Risk Analysis (PRA); Sanitary and

Phytosanitary System (SPS) – certificates; International Seed Health Initiative (ISHI) on seed health standards.

- Unit IV :Storage pests insects, mites, rodents and their development economic importance; insect infestation factors influencing, sources and kinds, biochemical changes in stored seeds due to insect infestation; detection methods and estimation of storage losses; types of seed storage structures domestic and commercial.
- Unit V :Fumigation principles and techniques type of fumigants; preservatives and seed protectants on seed quality non-chemical methods for managing seed storage pests controlled and modified atmospheric storage trapping devices IPM for seed storage.

## Practicals

- Detection of seed borne pathogens direct examination;
- Detection of seed borne pathogens incubation methods;
- Detection of seed borne pathogens serological methods;
- Detection of seed borne pathogens molecular methods;
- Study on seed transmission of seed borne fungi, bacteria and viruses;
- Identification of storage fungi;
- Management of seed borne pathogens seed treatment methods;
- Identification of storage insects internal and external feeders influencing insects;
- Study on the effect of pre harvest spray on field carryover storage pests;
- Estimation of storage losses due to pests;
- Methods of detection of insect infestation;
- Management of storage pests fumigation, chemical and non-chemical management methods;
- Demonstration of controlled atmospheric storage;
- Safe handling and use of fumigants and insecticides;
- Visit to seed storage godowns.

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Agarwal VK and Sinclair JB. 1996. *Principles of Seed Pathology*. Edition, CRC Press Inc. BocaRaton, FL.

- Athanassiou CG and Arthur FH. 2018. Recent advances in stored product protection. Springer- Verlag, Germany
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- Apple Academic Press, New York, USA.

Suggested e-books

https://link.springer.com/book/10.1007/978-1-349-02842-9 https://www.crcpress.com/Principles-of-Seed-Pathology/Agarwalinclair/p/book/97804291 52856 https://books.google.co.in/books/about/Seed\_Pathology.html?id=lvVJAAAAYAAJ &redir\_esc=y https://www.taylorfrancis.com/books/9781315365695 https://www.ebooks.com/en-us/610606/insects-of-stored-products/david-rees/ https://www.elsevier.com/books/insects-and-seed-collection-storage-testing-andcertification/kozlowski/978-0-12-395605-7

Suggested websites

www.tnagrisnet.tn.gov.in/

www.storedgrain.com.au/ https://openlibrary.org/subjects/seed \_pathology

http://ciat-

library.ciat.cgiar.org/articulos\_ciat/2015/12620 .pdf www.grainscanada.gc.ca/en/ https://entomology.ca.uky.edu/ef145 http://www.fao.org/3/t1838e/T1838E00.htm #Contents

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