PG Degree Programme Syllabus as per BSMA, ICAR
M.Sc. (Hort.) Vegetable Science

M.S. Swaminathan School of Agriculture
Centurion University of Technology and Management
Alluri Nagar, P.O. - R Sitapur, Via- Uppalada, Paralakhemundi
Dist: Gajapati – 761211
Odisha, India
2022

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Preamble

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

The country has witnessed a tremendous growth in vegetable production and productivity as a result of improved varieties/F1 hybrids /technologies through systematic research coupled with their large scale adoption by the farmers and developmental policies of government compared to area (2.84 m ha), production (16.5 mt) and productivity (5.8 t/ha) in 1950-51 there had been phenomenal increase in area (>3 folds; 10.1 m ha), production (>10 folds; 185 mt) and productivity (>3 folds; 18.0 t/ha) during 2017-18. Increasing percapita income, health conciousness, urbanisation, shifting of farmers to high value vegetables due to higher income, favourable income elasticity of demand and annual growth rate of domestic demand for vegetables are also important factors fueling its growth in the country.

During 2016-17, the total exports including potato and onion accounted for Rs 5922 crores sharing 35 per cent of total horticultural exports. With the current level of vegetable production in the country (171 mt), population (1.3 billion) and considering 25 percent postharvest losses and 5 percent export and processing, the per capita availability of vegetable production in our country is 250 g as against 300 g recommended dietary allowance (RDA). With projected population of 1.45 billion by 2030, India has to produce 210 mt of vegetables. The targeted production needs to be achieved through utilizing scientific technological and traditional strength in a sustainable manner without much increasing area under vegetables.

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

The course curriculum has been restructured to cover the current requirement of vegetable production and post-harvest management to increase capabilities of students. In order to

accomplish the task, either new courses have been formulated or existing course contents are upgraded to include latest developments in vegetables production.

In line with national policies, the existing course contents have been upgraded and five new courses viz., Principles of vegetable breeding, Breeding for special triats in Vegetable crops, Biodiversity and conservation of Vegetable crops, Biotechnological approaches in Vegetable crops and Advanced laboratory techniques for vegetable crops have been added. A course on Vegetable Breeding has been divided into two courses one for self-pollinated crops and another for cross pollinated vegetable crops. New components viz, hydroponics, aeroponics, grafting technique and precision farming have been added in appropriate courses. The overall up gradation of course contents as well as addition of courses are in line with national policy priorities like doubling of famer's income, more crop per drop, jaiveek krushi, soil health, skill development, entrepreneurship development, startup initiatives, etc.

Content

Framework of the courses

The following nomenclature and Credit Hrs. need to be followed while providing the syllabusfor all the disciplines

Course work	M.Sc. (Hort.) Credits
Major Courses	20
Minor Courses	08
Supporting Cources (S)	06
Common compulsory courses	05
Seminar	01
Thesis/Research	30
Total	**70**

M.Sc. (Hort.) Vegetable Science

Couse Code	Course Title	Credit	Page No.
	Major Courses		
HVSC 0501*	Production of Cool Season Vegetable Crops	2+1	7
HVSC 0502*	Production of Warm Season Vegetable Crops	2+1	8
HVSC 0503*	Growth and Development of Vegetable Crops	2+1	10
HVSC 0504*	Principles of Vegetable Breeding	3+0	12
HVSC 0505	Breeding of Self Pollinated Vegetable Crops	2+1	13
HVSC 0506	Breeding of Cross Pollinated Vegetable Crops	2+1	14
HVSC 0507	Protected Cultivation of Vegetable Crops	1+1	16
HVSC 0508	Seed Production of Vegetable Crops	2+1	18
HVSC 0509	Production of Underutilized Vegetable Crops	2+1	19
HVSC 0510	Systematics of Vegetable Crops	1+1	21
HVSC 0511	Organic Vegetable Production	1+1	22
HVSC 0512	Production of Spice Crops	2+1	23
HVSC 0513	Processing of Vegetable Crops	1+1	24
HVSC 0514	Postharvest Management of Vegetable Crops	2+1	26
HVSC 0591	Seminar	0+1	

HVSC 0599	Research	0+30	
Minor Courses			
MGPB 0501	Principles of Genetics	2+1	28
MGPB 0503	Fundamentals of Quantitative Genetics	2+1	29
MGPB 0504	Varietal Development and Maintenance Breeding	1+1	31
MMBB 0509	Plant Tissue Culture	2+1	32
MMBB 0501	Principles of Biotechnology	3+0	34
PGPP 0505	Hormonal Regulation of Plant Growth and Development	2+1	34
PGPP 0509	Physiology of Horticulture Crops	2+0	37
Supporting Courses			
STAT 0502	Statistical Methods for Applied Sciences	3+1	40
STAT 0511	Experimental Designs	2+1	41
STAT 0522	Data Analysis Using Statistical Packages	2+1	42
Common Courses			
PGSS 0501	Library and Information Services	0+1	43
PGSS 0502	Technical Writing and Communications Skills	0+1	44
PGSS 0503	Intellectual Property and its Management in Agriculture	1+0	45
PGSS 0504	Basic Concepts in Laboratory Techniques	0+1	46
PGSS 0505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0	47

***Indicates core course which is compulsory course for M. Sc. (Hort.)**

M. Sc. (Hort.) Vegetable Science

MAJOR COURSES

Course Code: HVSC 0501
Credit Hours: 2+1
Course Title: Production of Cool Season Vegetable Crops

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

Course outcomes: The students will know the packages of practices of cool season vegetables.

Theory

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

UNIT I

Bulb and tuber crops—Onion, garlic and potato.

UNIT II

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

UNIT III

Root crops—Carrot, radish, turnip and beetroot.

UNIT IV

Peas and beans—Garden peas and broad bean.

UNIT V

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

Practical

- Scientific raising of nursery and seed treatment;
- Sowing and transplanting;
- Description of commercial varieties and hybrids;
- Demonstration on methods of irrigation, fertilizers and micronutrients application;
- Mulching practices, weed management;

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

Suggested Reading

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. Vegetable crops. Vols. I-III. Naya udyog.
Bose TK, Som MG and Kabir J. (Eds.). 1993. Vegetable crops. Naya prokash. Chadha KL and Kalloo G. (Eds.). 1993-94. Advances in horticulture Vols. V-X. Malhotra publ. house.
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Fageria MS, Choudhary BR and Dhaka RS. 2000. Vegetable crops: production technology. Vol. II. Kalyani publishers.
Gopalakrishanan TR. 2007. Vegetable crops. New India publ. agency.
Hazra P and Banerjee MK and Chattopadhyay A. 2012. Varieties of vegetable crops in India, (Second edition), Kalyani publishers, Ludhiana, 199 p.
Hazra P. 2016. Vegetable Science. 2nd edn, Kalyani publishers, Ludhiana. Hazra P. 2019. Vegetable production and technology. New India publishing agency, New Delhi.
Hazra P, Chattopadhyay A, Karmakar K and Dutta S. 2011. Modern technology for vegetable production, New India publishing agency, New Delhi, 413p
Rana MK. 2008. Olericulture in India. Kalyani publishers, New Delhi.
Rana MK. 2008. Scientific cultivation of vegetables. Kalyani publishers, New Delhi.
Rana MK. 2014. Technology for vegetable production. Kalyani publishers, New Delhi.
Rubatzky VE and Yamaguchi M. (Eds.). 1997. World vegetables: principles, production and nutritive values. Chapman and Hall.
Saini GS. 2001. A text book of oleri and flori culture. Aman publishing house.
Salunkhe DK and Kadam SS. (Ed.). 1998. Hand book of vegetable science and technology: production, composition, storage and processing. Marcel dekker.
Shanmugavelu KG. 1989. Production technology of vegetable crops. Oxford and IBH.
Singh DK. 2007. Modern vegetable varieties and production technology. International book distributing Co.
Singh SP. (Ed.). 1989. Production technology of vegetable crops. Agril. comm. res. centre.
Thamburaj S and Singh N. (Eds.), 2004. Vegetables, tuber crops and spices. ICAR.
Thompson HC and Kelly WC. (Eds.). 1978. Vegetable crops. Tata McGraw-Hill.

Course Code: HVSC 0502
Credit Hours: 2+1
Course Title: Production of Warm Season Vegetable Crops

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

Course outcomes: The students will know the packages of practices of warm season vegetables.

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.

Practical

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

Suggested Reading

Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. Vegetable crops. Vols. I-III. Naya udyog.
Bose TK, Som MG and Kabir J. (Eds.). 1993. Vegetable crops. Naya prokash.
Chadha KL and Kalloo G. (Eds.). 1993-94. Advances in horticulture Vols. V-X. Malhotra publ. house.
Chadha KL. (Ed.). 2002. Hand book of horticulture. ICAR.
Chauhan DVS. (Ed.). 1986. Vegetable production in India. Ram prasad and sons.
Fageria MS, Choudhary BR and Dhaka RS. 2000. Vegetable crops: production technology. Vol. II. Kalyani.
Gopalakrishanan TR. 2007. Vegetable crops. New India publ. agency.
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Rana MK. 2008. Olericulture in India. Kalyani Publishers, New Delhi.
Rana MK. 2008. Scientific cultivation of vegetables. Kalyani Publishers, New Delhi.
Rubatzky VE and Yamaguchi M. (Eds.). 1997. World vegetables: principles, production and nutritive values. Chapman and Hall.
Saini GS. 2001. A text book of oleri and flori culture. Aman publishing house.
Salunkhe DK and Kadam SS. (Ed.). 1998. Hand book of vegetable science and technology: production, composition, storage and processing. Marcel dekker.
Shanmugavelu KG., 1989. Production technology of vegetable crops. Oxford and IBH.
Singh DK. 2007. Modern vegetable varieties and production technology. International book distributing Co.
Singh SP. (Ed.). 1989. Production technology of vegetable crops. Agril. comm. res. centre.
Thamburaj S and Singh N. (Eds.). 2004. Vegetables, tuber crops and spices. ICAR.
Thompson HC and Kelly WC. (Eds.). 1978. Vegetable crops. Tata McGraw-Hill.

Course Code: HVSC 0503
Credit Hours: 2+1
Course Title: Growth and Development of Vegetable Crops

Objective: To teach the physiology of growth and development of vegetable crops.

Course outcomes: This course will provide knowledge about basic cell functions, growth and development stages, roles and applications of plant growth regulators. It will also acquaint the students with basic physiological processes involved in flowering, fruit set and environmental factors associated.

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.

Practical

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

Suggested Reading

Bleasdale JKA. 1984. Plant physiology in relation to horticulture (2nd Edition) MacMillan.
Gupta US. Eds. 1978. Crop physiology. Oxford and IBH, New Delhi.
Kalloo G. 2017. Vegetable grafting: Principles and practices. CAB International
Krishnamoorti HN. 1981. Application growth substances and their uses in agriculture. Tata McGraw Hill, New Delhi.
Leopold AC and Kriedemann PE. 1981. Plant growth and development, Tata McGraw-Hill, New Delhi.
Peter KV and Hazra P. (Eds). 2012. Hand book of vegetables.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.

Peter KV. (Eds). 2008. Basics of horticulture. New India publication agency, New Delhi.
Rana MK. 2011. Physio-biochemistry and Biotechnology of Vegetables. New India Publishing Agency, Pritam Pura, New Delhi.
Saini et al. (Eds.). 2001. Laboratory manual of analytical techniques in horticulture. Agrobios, Jodhpur. Wien HC. (Eds.). 1997. The physiology of vegetable crops. CAB International.

Course Code: HVSC 0504
Credit Hours: 2+1
Course Title: Principles of Vegetable Breeding

Objective: To teach basic principles and practices of vegetable breeding.

Course outcomes: The students will be acquainted with the breeding principles and improvement of Vegetable crops.

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

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

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

UNIT IV
Mutation and Polyploidy breeding; Improvement of asexually propagated vegetable crops and vegetables suitable for protected environment.

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

Practical
• Floral biology and pollination behaviour of different vegetables;
• Techniques of selfing and crossing of different vegetables, viz., Cole crops, okra, cucurbits, tomato, eggplant, hot pepper, etc.;

• Breeding system and handling of filial generations of different vegetables;
• Exposure to biotechnological lab practices;
• Visit to breeding farms.

Suggested Reading

Allard RW. 1960. Principle of plant breeding. John Willey and Sons, USA.
Kalloo G. 1988. Vegetable breeding (Vol. I, II, III). CRC Press, Fl, USA.
Kole CR. 2007. Genome mapping and molecular breeding in plants-vegetables. Springer, USA.
Peter KVand Pradeep Kumar T. 1998. Genetics and breeding of vegetables. ICAR, New Delhi, p. 488.
Prohens J and Nuez F. 2007. Handbook of plant breeding-vegetables (Vol I and II). Springer, USA.
Singh BD. 2007. Plant breeding- principles and methods (8th edn.). Kalyani Publishers, New Delhi.
Singh Ram J. 2007. Genetic resources, chromosome engineering, and crop improvement-vegetable crops (Vol. 3). CRC Press, Fl, USA.

Course Code: HVSC 0505
Credit Hours: 2+1
Course Title: Breeding of Self Pollinated Vegetable Crops

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

Course outcomes: The students will be well acquainted with various methods adopted for improvement of Self-Pollinated vegetable crops.

Theory

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

UNIT I

Tuber crops: Potato.

UNIT II

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

UNIT III

Leguminous vegetables- Garden peas and cowpea.

UNIT IV

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

UNIT V

Leafy vegetables- Lettuce and fenugreek.

Practical

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

Suggested Reading

Allard RW. 1999. Principles of plant breeding. John Wiley and Sons.
Basset MJ. (Ed.). 1986. Breeding vegetable crops. AVI Publ.
Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005, Plant genetic resources: horticultural crops. Narosa Publ. House.
Fageria MS, Arya PS and Choudhary AK. 2000, Vegetable crops: Breeding and seed production. Vol. I. Kalyani.
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Hazra P and Som MG. 2015. Vegetable science (Second revised edition), Kalyani publishers, Ludhiana, 598 p.
Hazra P and Som MG. 2016. Vegetable seed production and hybrid technology (Second revised edition), Kalyani Publishers, Ludhiana, 459 p
Kalloo G. 1988. Vegetable breeding. Vols. I-III. CRC Press.
Kalloo G. 1998. Vegetable breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
Kumar JC and Dhaliwal MS. 1990. Techniques of developing hybrids in vegetable crops. Agro Botanical Publ. Paroda RS and Kalloo G. (Eds.). 1995. Vegetable research with special reference to hybrid technology in Asia-Pacific Region. FAO.
Peter KV and Pradeepkumar 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, 509 p.
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Rai N and Rai M. 2006. Heterosis breeding in vegetable crops. New India Publ. Agency.

Ram HH. 1998. Vegetable breeding: principles and practices. Kalyani Publishers, New Delhi. Simmonds NW. 1978. Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publishers, New Delhi.
Singh PK, Dasgupta SK and Tripathi SK. 2004. Hybrid vegetable development. International Book Distributing Co.
Swarup V. 1976. Breeding procedure for cross-pollinated vegetable crops. ICAR.

Course Code: HVSC 0506
Credit Hours: 2+1
Course Title: Breeding of Cross Pollinated Vegetable Crops

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

Course outcomes: The students will be well acquainted with various methods adopted for improvement of Cross-Pollinated vegetable crops.

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

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

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

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

UNIT IV
Tuber crops—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 in vegetable crops and special breeding techniques
- Visit to breeding blocks.

Suggested Reading

Allard RW. 1999. Principles of plant breeding. John Wiley and Sons.
Basset MJ. (Ed.). 1986. Breeding vegetable crops. AVI Publ.
Dhillon BS, Tyagi RK, Saxena S and Randhawa GJ. 2005. Plant genetic resources: horticultural crops. Narosa publ. house.
Fageria MS, Arya PS and Choudhary AK. 2000. Vegetable crops: breeding and seed production. Vol. I. Kalyani.
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Hayes HK, Immer FR and Smith DC. 1955. Methods of plant breeding. McGraw-Hill.
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Kumar JC and Dhaliwal MS. 1990. Techniques of developing hybrids in vegetable crops. Agro botanical publ
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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.
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Rai N and Rai M. 2006. Heterosis breeding in vegetable crops. New India Publ. Agency.
Ram HH. 1998. Vegetable breeding: principles and practices. Kalyani Publishers, New Delhi.
Simmonds NW. 1978. Principles of crop improvement. Longman.
Singh BD. 1983. Plant breeding. Kalyani Publishers, New Delhi.
Singh PK, Dasgupta SK and Tripathi SK. 2004. Hybrid vegetable development. International book distributing Co.
Swarup V. 1976. Breeding procedure for cross-pollinated vegetable crops. ICAR.
Swarup V. 1976. Breeding procedure for cross-pollinated vegetable crops. ICAR.

Course Code: HVSC 0507
Credit Hours: 2+1
Course Title: Protected Cultivation of Vegetable Crops

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

Course outcomes: This course will provide knowledge about production of high value crops all around the year under protected environmental conditions.

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

UNIT VI

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

Practical

- 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 Reading

Chadha KL and Kalloo G. (Eds.). 1993-94. Advances in horticulture. Malhotra Pub. House.
Chandra S and Som V. 2000. Cultivating vegetables in green house. Indian horticulture 45:17- 18. Kalloo G and Singh K. (Eds.). 2000. Emerging scenario in vegetable research and development.Research periodicals and Book publ. house
Parvatha RP. 2016. Sustainable crop protection under protected cultivation. E-Book Springer.
Prasad S and Kumar U. 2005. Greenhouse management for horticultural crops. 2nd Ed.Agrobios. Resh HM. 2012. Hydroponic food production. 7thEdn. CRC Press.
Singh B. 2005. Protected cultivation of vegetable crops. Kalyani publishers, New Delhi
Singh DK and Peter KV. 2014. Protected cultivation of horticultural crops (1st Edition) New India publishing agency, New Delhi
Singh S, Singh B and Sabir N. 2014. Advances in protected cultivation. New India publishing agency, New Delhi.
Tiwari GN. 2003. Green house technology for controlled environment. Narosa publ. house.

Course Code: HVSC 0508
Credit Hours: 2+1
Course Title: Seed Production of Vegetable Crops

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

Course outcomes: The students will be acquainted with importance of quality seed production various methods of seed production in self and open pollinated crops.

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

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

UNIT III

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

UNIT IV

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

UNIT V

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

Practical

- 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 Reading

Agarwaal PK 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.

Bench ALR and Sanchez RA. 2004. Handbook of seed physiology. Food products press, NY/ London. Bendell PE. (Eds.). 1998. Seed science and technology: Indian forestry species. Allied Publ. Chakraborty SK, Prakash S, Sharma SP and Dadlani M. 2002. Testing of distinctiveness, uniformity and stability for plant variety protection. IARI, New Delhi

Copland LO and McDonald MB. 2004. Seed science and technology, Kluwer Academic Press.

Fageria MS, Arya PS and Choudhary AK. 2000. Vegetable crops: breeding and seed production. Vol. I. Kalyani Publishers, New Delhi.
George RAT. 1999. Vegetable seed production (2nd Edition). CAB International.
Kalloo G, Jain SK, Vari AK and Srivastava U. 2006. Seed: A global perspective. Associated publishing company, New Delhi.
Hazra P and Som HG. 2015. Seed production and hybrid technology of vegetable crops. Kalyani publishers, Ludhiana.
Kumar JC and Dhaliwal MS. 1990. Techniques of developing hybrids in vegetable crops. Agro botanical publ.
More TA, Kale PB and Khule BW. 1996. Vegetable seed production technology. Maharashtra state seed corp.
Rajan S and Markose BL. 2007. Propagation of horticultural crops. New India publ. agency.
Singh NP, Singh DK, Singh YK and Kumar V. 2006. Vegetable seed production technology. International book distributing Co.
Singh SP. 2001. Seed production of commercial vegetables. Agrotech publ. academy.
Singhal NC. 2003. Hybrid seed production. Kalyani publishers, New Delhi

Course Code: HVSC 0509
Credit Hours: 2+1
Course Title: Production of Underutilized Vegetable Crops

Course outcomes: The students will be well versed with package of practices of under exploited vegetables so as to enhance their production.

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

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

Practical

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

Suggested Reading

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: 9781138035218
Rubatzky VE and Yamaguchi M. 1997. World vegetables: vegetable crops. NBPGR, New Delhi.

Course Code: HVSC 0510
Credit Hours: 1+1
Course Title: Systematics of Vegetable Crops

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

Course outcomes: The students will be aware of the origin and evolution of different vegetables

Theory
UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Cytology—Cytological level of various vegetable crops with descriptive keys UNIT V Molecular markers—Importance of molecular markers in evolution of vegetable crops; Molecular markers as an aid in characterization and taxonomy of vegetable crops

Practical

- 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 Reading

Chopra GL. 1968. Angiosperms- systematics and life cycle. S. Nagin
Dutta AC. 1986. A class book of botany. Oxford Univ. Press.
Pandey BP. 1999. Taxonomy of angiosperm. S. Chand and Co
Peter KV and Pradeepkumar 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, Gangopadyay 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.

Course Code: HVSC 0511
Credit Hours: 1+1
Course Title: Organic Vegetable Production

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

Course outcome: The students will be well versed with package of practices of vegetable crops organically.

Theory

UNIT I

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

UNIT II

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

UNIT III

Managing soil fertility—Managing soil fertility, mulching, raising green manure crops, weed management in organic farming system; Crop rotation in organic production; Processing and quality control of organic vegetable produce

UNIT IV

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

UNIT V

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

Practical

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

Suggested Reading

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

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

Palaniappan SP and Annadorai K. 2003. Organic farming, theory and practice. Scientific publ. Pradeepkumar T, Suma B, Jyothibhaskar and Satheesan KN. 2008. Management of horticultural crops. New India Publ. Agency.

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

Course Code: HVSC 0512

Credit Hours: 2+1

Course Title: Production of Spice Crops

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

Course outcomes: The students will be acquainted with the production technology of important Spice crops.

Theory

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

UNIT I

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

UNIT II

Bud and kernel- Clove and nutmeg

UNIT III

Underground spices- Turmeric, ginger and garlic

UNIT IV

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

UNIT V

Tree spices- Cinnamon, tamarind, garcinia and vanilla

Practical

- 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 Reading

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

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

Bhattacharjee SK. 2000. Hand book of aromatic plants. Pointer publications.
Bose TK, Mitra SK, Farooqi SK and Sadhu MK. (Eds.). 1999. Tropical horticulture.Vol.I. Naya Prokash.
Chadha KL and Rethinam P. (Eds.). 1993. Advances in horticulture. Vols. IX-X. Plantation crops and spices. Malhotra Publ. House.
Gupta S. (Ed.). Hand book of spices and packaging with formulae. engineers India research institute, New Delhi.
Kumar NA, Khader P, Rangaswami and Irulappan I. 2000. Introduction to spices, plantation crops, medicinal and aromatic plants. Oxford and IBH.
Nybe EV, Miniraj N and Peter KV. 2007. Spices. New India Publ. Agency.
Parthasarthy VA, Kandiannan V and Srinivasan V. 2008. Organic spices. New India Publ. Agency. Peter KV. 2001. Hand book of herbs and spices. Vols. I-III. Woodhead Publ. Co. UK and CRC USA. Pruthi JS. (Ed.). 1998. Spices and condiments. National Book Trust
Pruthi JS. 2001. Minor spices and condiments- crop management and post harvest technology. ICAR.
Purseglove JW, Brown EG, Green CL and Robbins SRJ. (Eds.). 1981. Spices. Vols. I, II. Longman. Shanmugavelu KG, Kumar N and Peter KV. 2002. Production technology of spices and plantation crops. Agrobios.
Thamburaj S and Singh N. (Eds.). 2004. Vegetables, tuber crops and spices. ICAR.
Tiwari RS and Agarwal A. 2004. Production technology of spices. International Book Distr. Co. Varmudy V. 2001. Marketing of spices. Daya Publ. House

Course Code: HVSC 0513
Credit Hours: 1+1
Course Title: Processing of Vegetable Crops

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

Course outcomes: The students will be acquainted with various ways of increasing shelf life and value addition of vegetables.

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

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

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

UNIT IV

Quality control—Quality assurance and quality control, TQM, GMP; Food standardsFPO, 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 Reading

Arthey D and Dennis C. 1996. Vegetable processing. Blackie/ Springer-Verlag.
Chadha DS. 2006. The Prevention of food adulteration act. Confed. of Indian Industry.
Desrosier NW. 1977. Elements and technology. AVI Publ. Co
FAO. 1997. Fruit and Vegetable processing.
FAO. FAO. CODEX Alimentarius: Joint FAO/ WHO food standards programme. 2nd Ed. Vol. VB. tropical fresh fruits and vegetables.
FAO. FAO. Food quality and safety systems- training manual on food hygiene and haccp. FAO.
Fellow's P. 1988. Food processing technology. Ellis Horwood International.
Frazier WC and Westhoff DC. 1995. Food microbiology. 4th Ed. Tata McGraw Hill.
Giridharilal GS Siddappa and Tandon GL. 1986, Preservation of fruits and vegetables. ICAR.
Gisela J. 1985. Sensory evaluation of food- theory and practices. Ellis Horwood.
Graham HD. 1980. Safety of foods. AVI Publ. Co.
Hildegrade H and Lawless HT. 1997. Sensory evaluation of food. CBS.
Joslyn M and Heid Food processing operations.AVI Publ. Co
Mahindru SN. 2004. Food safety: concepts and reality. APH Publ. Corp.
Ranganna S. 1986. Handbook of analysis and quality control for fruit and vegetable products. 2nd Ed. Tata-McGraw Hill
Shapiro R. 1995. Nutrition labeling handbook. Marcel Dekker.
Srivastava RP and Kumar S. 2003. Fruit and vegetable preservation: principles and practices. 3rd Ed. International Book Distri. Co

Course Code: HVSC 0514

Credit Hours: 2+1
Course Title: Postharvest Management of Vegetable Crops

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

Course outcomes: The students will know the various ways for value addition in vegetable crops.

Theory
UNIT I
Importance and scope—Importance and scope of post-harvest management of vegetables

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

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

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 packinghouse, cold storage and control atmosphere storage.

Suggested Reading

Chadha KL and Pareek OP. 1996. Advances in horticulture. Vol. IV. Malhotra Publ. House.
Chattopadhyay SK. 2007. Handling, transportation and storage of fruit and vegetables. GeneTech books, New Delhi.
Haid NF and Salunkhe SK. 1997. Postharvest physiology and handling of fruits and vegetables. Grenada Publ.
Mitra SK. 1997. Postharvest physiology and storage of tropical and sub-tropical fruits. CABI.
Paliyath G, Murr DP, Handa AK and Lurie S. 2008. Postharvest biology and technology of Fruits, vegetables and flowers. Wiley-Blackwell, ISBN: 9780813804088.
Ranganna S. 1997. Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw-Hill.
Stawley JK. 1998. Postharvest physiology of perishable plant products. CBS publishers.
Sudheer KP and Indira V. 2007. Postharvest technology of horticultural crops. New India Publ. Agency.
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.

MINOR COURSES

Course Code: MGPB 0501
Credit Hours: 2+1
Course Title: Principles of Genetics

Objective: To understand the basic concepts of inheritance of genetic traits, helping students to develop their analytical, quantitative and problem-solving skills from classical to molecular genetics.

Course outcomes: This course will provide knowledge about gaining of knowledge of the

basic principles of inheritance and variation along with the molecular genetics.

Theory

UNIT I

Beginning of genetics**,** early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance; Multiple alleles, Gene interactions, Sex determination, differentiation and Sex-linkage, Sex-influenced and Sex-limited traits; Linkage- detection and estimation; Recombination and genetic mapping in eukaryotes, Somatic cell, Extra chromosomal inheritance.

UNIT II

Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.

UNIT III

Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis, Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Ontogenesis, Gene families and clusters; Regulation of gene activity in prokaryotes and eukaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression, RNA editing.

UNIT IV

Gene isolation, synthesis and cloning, Genomic and cDNA libraries, PCR based cloning, Positional cloning; Nucleic acid hybridization and Immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro-RNAs (miRNAs).

UNIT V

Genomics and Proteomics; Metagenomics; Transgenic bacteria and Bioethics; Gene silencing; Genetics of Mitochondria and Chloroplasts. Concepts of Eugenics, Epigenetics, Genetic disorders.

Practical

- Laboratory exercises in probability and chi-square
- Demonstration of genetic principles using laboratory organisms
- Chromosome mapping using three-point test cross
- Tetrad analysis
- Induction and detection of mutations through genetic test
- DNA extraction and PCR amplification
- Electrophoresis: basic principles and running of amplified DNA
- Extraction of proteins and isozymes
- Use of *Agrobacterium* mediated method and Biolistic gun
- Detection of transgenes in the exposed plant material
- Visit to transgenic glasshouse and learning the practical considerations.

Teaching methods: Classroom teaching with AV aids, group discussion,assignment and

class discussion

Learning outcome: After passing out this course the student will be able to know the difference between the genotype and phenotype can carry study on inheritance and also know the role of DNA and RNA in genotypic manifestation of characters.

Suggested reading

Daniel LH and Maryellen R. 2011. *Genetics: –Analysis of Genes and Genomes*.

Gardner EJ and Snustad DP. 1991. *Principles of Genetics*. John Wiley and Sons. 8th ed. 2006 Klug WS and Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu. Pearson Education India; Tenth edition

Lewin B. 2008. *Genes XII*. Jones and Bartlett Publ. (International Edition) Paperback, 2018Russell 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; 7edition

Uppal S, Yadav R, Singh S and Saharan RP. 2005. *Practical Manual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

Course Code: MGPB 0503

Credit Hours: 2+1

Course Title: Fundamentals of Quantitative Genetics

Objective: To impart theoretical knowledge and computation skills regarding components of variation andvariances, scales, mating designs and gene effects.

Course outcomes: The student will be equipped with the knowledge of additive dominance and epistatic gene action. He will also be introduced with the various designs for analysis of genotypic and phenotypic variance and QTL mapping.

Theory

UNIT I

Introduction and historical background of quantitative genetics, Multiple factor hypothesis, Qualitative and quantitative characters, Analysis of continuous variation mean, range, SD, CV; Components of variation- Phenotypic, Genotypic, Nature of gene action- additive, dominance and epistatic, linkage effect. Principles of analysis of variance and linear model, Expected variance components, Random and Fixed effect model, Comparison of means and variances for significance.

UNIT II

Designs for plant breeding experiments- principles and applications; Variability parameters,

concept of selection, simultaneous selection modes and selection of parents, MANOVA.

UNIT III

Association analysis- Genotypic and phenotypic correlation, Path analysis Discriminate function and Principal component analysis, Genetic divergence analysis- Metroglyph and D^2, Generation mean analysis, Parent progeny regression analysis

UNIT IV

Mating designs- classification, Diallel, Partial diallel, L × T, NCDs, and TTC; Concept of combining ability and gene action, G × 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.

Practical

- Analysis and interpretation of variability parameters
- Analysis and interpretation of Index score and Metroglyph
- Clustering and interpretation of D^2 analysis
- Genotypic and Phenotypic correlation analysis and interpretation
- Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation
- A, B and C Scaling test
- L × T analysis and interpretation, QTL analysis;Use of computer packages
- Diallel analysis
- G × E interaction and stability analysis

Teaching methods: Classroom teaching with AV aids, group discussion,assignment and class discussion

Learning outcome: After studying this course, the student will be equipped with the knowledge of additive dominance and epistatic gene action. He will also be introduced with the various designs for analysis of genotypic and phenotypic variance and QTL mapping.

Suggested Reading

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

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

Mather K and Jinks JL.1985. *Biometrical Genetics* (3rd Ed.). Chapman and Hall, London.

Nandarajan N and Gunasekaran M. 2008. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.

Naryanan SS and Singh P. 2007. *Biometrical Techniques in Plant Breeding*. Kalyani Publishers, New Delhi.

Roy D. 2000. *Plant Breeding: Analysis and Exploitation of Variation*. Narosa Publishing

House,New Delhi.
Sharma JR. 2006. *Statistical and Biometrical Techniques in Plant Breeding*. New Age International Pvt. Ltd.
Singh P and Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding.* Kalyani Publishers, New Delhi.
Singh RK and Chaudhary BD. 1987. *Biometrical Methods in Quantitative Genetic* analysis. Kalyani Publishers, New Delhi.
Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
Wricke G and Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*.

Suggested Website
www.iasri.icar.gov.in www.hau.ac.in/OPstat

Course Code: MGPB 0504
Credit Hours: 1+1
Course Title: Varietal Development and Maintenance Breeding

Objective: The purpose of this course is to make students well acquainted with the techniques and procedures of varietal development. He will be associated with development of variety so the course aims is to provide knowledge on DUS testing, protocols of various breeding techniques, procedures of release of variety, maintenance of the variety and production of nucleus and breeder seed of variety/ hybrids.

Course outcomes: Student will have complete knowledge on development and release of variety and also make student acquainted with the seed laws and acts related to plant variety protection.

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, certified.

UNIT IV
Quality seed production technology of self and cross-pollinated crop varieties, viz., Cereals

and Millets (wheat, barley, paddy, pearl millet, sorghum, maize and ragi, etc.); Pulses (green gram, black gram, cowpea, pigeon pea, chickpea, field pea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); Fibres (cotton/jute) and Forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).

UNIT V

Seed certification procedures; Seed laws and acts, Plant variety protection regulations in India and international systems. Identification of suitable areas/ locations for seed production.

Practical

- Ear-to-row method and 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 crops;
- Variety release proposal formats in different crops

Teaching methods: Classroom teaching with AV aids, group discussion,assignment and class discussion

Learning outcome: Pass out student will have complete knowledge on the various procedures linked with the development and release of variety. This course will also enable student how to maintain and multiply variety for large scale distribution. It will also make student acquainted with the seed laws and acts related to plant variety protection.

Suggested Reading

Agarwal RL. 1997. *Seed Technology*. 2nd Ed. OXford & IBH.
Kelly AF. 1988. *Seed Production of Agricultural Crops*. Longman.
Mc Donald 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.

Course Code: MMBB 0509
Credit Hours: 2+1
Course Title: Plant Tissue culture

Objectives: To provide insight into principles of plant cell culture and genetic transformation, to get a hands on training in basic plant tissue culture techniques, callusing,micro propagation and analysis.

Course outcomes: The students will be acquainted with principles of plant cell culture and basic plant tissue culture techniques.

Theory

UNIT I

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

Micro propagation of field and ornamental crops; Virus elimination by meristem culture, meristemtip 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

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

Practical

- Preparation of stocks - macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium. 2.Micro-propagation of plants by nodal and shoot tip culture.
- Embryo culture to overcome incompatibility, Anther culture for haploid production. 4.Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis.
- 5.Acclimatization of tissue culture plants and establishment in greenhouse. 6.Virus indexing in tissue culture plants. (Using PCR and ELISA).
- 7.Plan of a commercial tissue culture unit.

Suggested Reading

Razdan, M. K. (2003) Introduction to plant tissue culture, 2nd edition, Oxford publications group

Butenko, R. G. (2000)Plant Cell CultureUniversity 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.

Course Code: MMBB 0501
Credit Hours: 3+0
Course Title: Principles of Biotechnology

Objectives: To understand the basics of Molecular biology, plant and microbial Biotechnology, importance and applications in agriculture, case studies and success stories, public education, perception, IPR and related issues

Course outcomes: The student will be equipped with the knowledge of Analyzing the functioning of life at cellular level.

Theory

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. Plant cell and tissue culture techniques and their applications.

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 Reading

Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M &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, S. B. and Twyman, R. (2006) Principles of gene Manipulation 7th edition, Wiley Blackwell
Singh, B. D, Biotechnology: Expanding Horizons (2012) 4th edition, Kalyani publisher, New Delhi, India

Course Code: PGPP 0505
Credit Hours: 2+1
Course Title: Hormonal Regulation of Plant Growth and Development

Objective: It provides knowledge on the fundamentals of hormone biosynthesis, homeostasis, transport and signaling and the role in regulating basic physiological processes governing developmental events in plants. The role of classical hormones on developmental processes from germination, shoot and root apical meristem differentiation, flowering, seed maturation and senescence. The aim of this course is to appraise the students about structure and function of plant growth regulators. The course is organized as follows:

A. Plant Growth and Development:

1. Introduction to Plant Hormones Hormonal Regulation
2. Plant Hormones - Discovery and Metabolism
3. Physiological Role of Hormones in Plant Growth and Development
4. Endogenous Growth Substances other than Hormones
5. Hormone Signaling
6. Key Genes Regulating Hormone Levels and Functions
7. Crosstalk of Hormones in Regulation of Plant Growth and Development Processes
8. Practical Utility of Growth Regulators in Agriculture and Horticulture

Course outcomes: It covers the physiological processes involved in plant growth and development, the role of different hormones.

Theory
Block 1: Plant Growth and Development: Hormonal Regulation
UNIT I
Introduction to Plant Hormones Growth, differentiation and development regulated by plant growth substances, Definition and classification of growth regulating substances: Classical hormones, Definition and classification of growth regulating substances: Endogenous growth substances other than hormones, Synthetic chemicals.

UNIT II
Plant Hormones – Discovery and Metabolism Discovery, biosynthetic pathways and metabolism of Auxin, Discovery, biosynthetic pathways and metabolism of Gibberellins, Discovery, biosynthetic pathways and metabolism of Cytokinins, Discovery, biosynthetic pathways and metabolism of Abscisic acid, Discovery, biosynthetic pathways and metabolism of Ethylene, Discovery, biosynthetic pathways and metabolism of Brassinosteroids, Discovery, biosynthetic pathways and metabolism of Strigolactones.

UNIT III

Physiological Role of Hormones in Plant Growth and Development Physiological functions of Auxin and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Gibberellins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Cytokinins and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Abscisic acid and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Ethylene and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Brassinosteroidsand Strigolactones and use of mutants and transgenic plants in elucidating the physiological functions, Discovery, biosynthetic pathways metabolism and physiological roles of Salicylic acid and Peptide hormones.

UNIT IV

Endogenous Growth Substances other than Hormones Discovery, biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins, Discovery, biosynthetic pathways metabolism and physiological roles of Jasmonates and Tricontanol, Discovery, biosynthetic pathways metabolism and physiological roles of systemins Concept of death hormone, Recent developments in elucidating responses of Salicylic acid, Peptide hormones and Polyamines at physiological and molecular level, Recent developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricontanol at physiological and molecular level.

UNIT V

Hormone Signaling Hormone signal perception, transduction - Receptors, components and mechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid), Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones), Advances in elucidating the structure and function of receptors and signaling components of important hormones.

UNIT VI

Key Genes Regulating Hormone Levels and Functions Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies.

UNIT VII

Crosstalk of Hormones in Regulation of Plant Growth and Development Processes Crosstalk of Hormones in Regulation of Plant Growth and Development Processes: Floral transition, reproductive development, Shoot and root apical meristem development

UNIT VIII

Practical Utility of Growth Regulators in Agriculture and Horticulture Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings, Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits, Practical Utility of Growth Regulators in Agriculture and Horticulture:

Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop.

Practical

• Extraction of Auxins from plant tissue
• Separation and detection of Auxins by GC / GC-MS / HPLC / Immunological technique
• Bioassay of auxin- effect on rooting of cuttings
• Extraction of abscisic acid (ABA) from plant tissue
• Separation and detection of ABA by HPLC/Immunological technique
• ABA bioassays- effect on stomatal movement
• Preparation of samples for ethylene estimation in plant tissue
• Estimation of ethylene in plant tissues using gas chromatography
• Ethylene bioassays, estimation using physico-chemical techniques- effect on breaking dormancy in sunflower and groundnut
• Extraction of Gibberellins from plant tissue- GC / GC-MS / HPLC
• Separation and detection of GA by GC / GC-MS / HPLC/Immunological technique
• GA bioassays- effect on germination of dormant seeds
• Cytokinin- extraction from plant tissue
• Separation and detection of cytokinin by GC / GC-MS / HPLC
• Cytokinin bioassays- effect on apical dominance and senescence / stay green

Suggested Reading

Davies P.J. 2004, Plant Hormones: Biosynthesis, Signal Transduction and Action, 2nd Edition. Kluwer Academic Publishers, Dordrecht, The Netherlands.
Hedden, P. and Thomas, S.J. 2006. Plant Hormone Signalling, Blackwell Publishing Ltd., Oxford, UK.
Osborne, D.J. and McManus, M.T. 2005. Hormones, Signals and Target Cells in Plant Development. Cambridge University Press, New York, USA.
Tucker, G.A. and Roberts, J.A. 2000. Plant Hormone Protocols. Humana Press-Springer Science, New York, USA.
Buchanan B B, Gruissem W and Jones R L. Biochemistry and Molecular biology of Plants, 2nd Edition
Lincoln Taiz and Eduardo Zeiger. Plant Physiology and Development, 6th Edition.
Teaching Tools in Plant Biology, The American Society of Plant Biologists
The Arabidopsis Book (http://www.arabidopsisbook.org/).

Course Code: PGPP 0509
Credit Hours: 2+0
Course Title: Physiology of Horticulture Crops

Objectives: This course should provide a broad exposure on the physiological aspects of horticulture crops. The objective is to impart comprehensive information on physiological processes and physiological basis of growth, development and productivity of horticultural crop plants.

Physiology of Horticultural Crops

1. Introduction
2. Crop growth and Development
3. Reproductive Growth
4. Pre and Post-harvest Physiology
5. Plant Nutrition and Abiotic Stress Responses
6. Specific Aspects and Unique Crop Feature

Course outcomes: The students will be acquainted with knowledge about growth, development and yield of different horticultural crops

Theory

Block 1: Physiology of Horticultural Crops

UNIT I

Introduction Origin, distribution and adaptability of crops to different agro-climatic conditions

UNIT II

Crop growth and Development Internal factors (hormone, etc.) influencing various physiological processes linked to vegetative growth or growth of specific organ, correlative and algometric growth External factors (water, nutrition, temperature, etc.) influencing various physiological processes linked to vegetative growth or growth of specific organ, correlative and algometric growth, Propagation methods, grafting, cutting, budding, air layering. Physiology of pruning, dwarfing, branch bending, canopy management etc., Physiological and biochemical aspects of scion and root stock interaction and compatibility.

UNIT III

Reproductive Growth Physiology of flowering, photo- and thermo-periodism and response to vernalization, Factors influencing reproductive growth, fruit and seed set/retention, physiology of flower sex ratio, Physiological processes governing source-sink relationship and productivity.

UNIT IV

Pre and Post-Harvest Physiology Preharvest factors influencing postharvest physiology, Physiological and molecular mechanisms of ripening, Physiological and molecular mechanisms of senescence, Hormonal and chemical control of postharvest deterioration of fruits/vegetable/ flowers. Regulation of ripening at physiological and molecular levels, Regulation of senescence at physiological and molecular levels, Approaches to improve shelf life and storability. Approaches to improve postharvest management, Approaches to improve processing and value addition.

UNIT V

Plant Nutrition and Abiotic Stress Responses Nutrient acquisition and requirement, plant phenology and nutrient requirement; Role of rootstocks in nutrient acquisition and in abiotic stress tolerance, Adaptive mechanisms and approaches to improve performances under drought and high temperature, Adaptive mechanisms and approaches to improve

performances under frost, chilling and nutrient deficient conditions, Root physiology in abiotic stress tolerance.

UNIT VI

Specific Aspects and Unique Crop Features

Specific aspects

Polyhouse cultivation, Hormones/PGRs for improving crop performance, Major and micronutrients for improving crop performance, Light interception, shade regulation, dwarfing root stocks, Chilling requirement for flowering, photoperiodic response, pollen viability, stigma receptivity, Flower (blossom) and fruit drop.

Unique crop features

Maturity and maturity indices, Source-sink relations, Vegetative propagation, Physiology of tuberization and rhizome initiation and formation, Virus free planting material, Bulbs/tubers dormancy, bud break, Physiological disorders, Storage, Packaging, Quality.

Suggested Reading

Sethuraj MR and Raghavendra AS. 2012. Tree Crop Physiology. ISBN-13: 978-0444428417, ISBN-10: 0444428410, Elsevier Science Publishers.

Bhatnagar P. Physiology of Growth and Development of Horticultural Crops, ISBN-10: 817754666X, ISBN-13: 978-8177546668

Singh A. Fruit Physiology and Production, ISBN-10: 8127211788, ISBN-13: 978-8127211783, Kalyani Publishers; 5th edition (March 28, 2003).

Hare K. 2012. Physiology of Fruit Production, ISBN-10: 9380012373, ISBN-13: 978-9380012377, Studium Press India Pvt. Ltd

Durner EF. 2013. Principles of Horticultural Physiology, ISBN-13: 978-1780643069, ISBN10: 1780643063, CABI.

Bleasdale JKA. Plant Physiology in Relation to Horticulture, ISBN-10: 8192686094, ISBN13: 978-8192686097, SENTIFIC (2014) 2nd edition

Kumar M. 2015. Physiology of Fruit Production, ISBN-10: 9384568384, ISBN-13: 978-9384568382.

Yahia EM and Carrillo-Lopez A. 2018. Postharvest Physiology and Biochemistry of Fruits and Vegetables, ISBN-10: 0128132787, ISBN-13: 978-0128132784, Woodhead Publishing.

Freitas ST and Pareek S. Postharvest Physiological Disorders in Fruits and Vegetables, ISBN-9781138035508, 1138035505, Taylor and Francis Ltd.

Dhillon WS and Bhat ZA. 2012. Fruit Tree Physiology. Narendra Publishing House.

Sandip M, Makwana AN, Barad AV and Nawade BD. 2015. Physiology of flowering–the case of mango. Int. J. Appl. Res, 1(11), 1008-1012.

Schaffer B and Andersen PC. 2018. Handbook of environmental physiology of fruit crops. CRC Press.

Lakshminarayana S, Subhadra NV and Subramanyam H. 1970. Some aspects of developmental physiology of the mango fruit. Journal of Horticultural Science, 45(2), 133-142.

SWAMY JS. 2012. Flowering manipulation in mango: A science comes of age. Journal of Today's Biological Sciences: Research and Review, New Delhi, 1(1), 122-137.

Singh VK and Sharma K. 2008. Physiological and biochemical changes during flowering of mango (Mangifera indica l.). International Journal of Plant Developmental Biology, 2(2), 100-105.
Carr MKV. 2014. The water relations and irrigation requirements of mango (Mangifera indica L.): a review. Experimental Agriculture, 50(1), 1-23.
Hagemann MH, Roemer MG, Kofler J, Hegele M and Wünsche JN. 2014. A new approach for analysing and interpreting data on fruit drops in mango. HortScience, 49(12), 1498- 1505.
Ramírez F and Davenport TL. 2010. Mango (Mangifera indica L.) flowering physiology. Scientia Horticulturae, 126(2), 65-72.
Léchaudel M, Lopez-Lauri F, Vidal V, Sallanon H and Joas J. 2013. Response of the physiological parameters of mango fruit (transpiration, water relations and antioxidant system) to its light and temperature environment. Journal of plant physiology, 170(6), 567-576.
Urban L, Jegouzo L, Damour G, Vandame M and François C. 2008. Interpreting the decrease in leaf photosynthesis during flowering in mango. Tree physiology, 28(7), 1025-1036.
Jameel MA, Naik SR, Madhumathi C, Reddy DS and Venkataramana KT. 2018. Physiology of flowering in mango. Journal of Pharmacognosy and Phytochemistry, 7(6), 2375-2382.
Lin HL, Shiesh CC and Chen PJ. 2012. May. Physiological disorders in relation to compositional changes in mango (Mangiferaindica L.'Chiin Hwang') fruit. In VII International Symposium on Mineral Nutrition of Fruit Crops 984 (357-363).
Dayal V, Dubey AK, Singh SK, Sharma RM, Dahuja A and Kaur C. 2016. Growth, yield and physiology of mango (Mangifera indica L.) cultivars as affected by polyembryonic rootstocks. Scientia horticulturae, 199, 186-197.

SUPPORTRING COURSES

Course Code: STAT 0502
Credit Hours: 3+1
Course Title: Statistical Methods for Applied Sciences

Objectives: This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.
Course outcomes: This course will provide knowledge about basic statistical methods and their applications in real world.

Theory
UNIT I
Box-plot, Descriptive statistics, Exploratory data analysis, Theory of probability, Random variable and mathematical expectation.

UNIT II

Discrete and continuous probability distributions, Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions.

UNIT III

Introduction to theory of estimation and confidence-intervals, Simple and multiple correlation coefficient, partial correlation, rank correlation, Simple and multiple linear regression model, test of significance of correlation coefficient and regression coefficients, Coefficient of determination, Fitting of quadratic models.

UNIT IV

Non-parametric tests – sign, Wilcoxon, Mann-Whitney U-test, Run test for the randomness of a sequence. Median test. Unit V Introduction to ANOVA: One way and Two Way, Introduction to Sampling Techniques, Introduction to Multivariate Analysis, Transformation of Data.

Practical

• Exploratory data analysis, fitting of distributions ~ Binomial, Poisson, Negative Binomial, Normal.
• Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F.
• Confidence interval estimation and Correlation and regression analysis, fitting of Linear and Quadratic Model.
• Non-parametric tests. ANOVA: One way, Two Way, SRS.

Suggested Reading

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

Course Code: STAT 0511
Credit Hours: 2+1
Course Title: Experimental Designs

Objective: This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Course outcomes: The students will learn about designing the experiments and also statistical tools to get maximum information from least number of resources.

Theory

UNIT I

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

UNIT II

Uniformity trials, size and shape of plots and blocks, Analysis of variance, Completely randomized design, randomized block design and Latin square design.

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom. Concept of confounding.

UNIT IV

Split plot and strip plot designs, analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, Balanced Incomplete Block Design, resolvable designs and their applications, Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Combined analysis.

Practical

• Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD, Analysis of factorial experiments,
• Analysis with missing data,
• Split plot and strip plot designs.

Suggested Reading

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.

Course Code: STAT 0522
Credit Hours: 2+1
Course Title: Data Analysis Using Statistical Packages

Objective: This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students hands on experience in the analysis of their research data. This course is useful to all disciplines.

Course outcomes: Students will get the ability to analyze data using different statistical methods and programmes.

Theory
UNIT I
Introduction to various statistical packages: Excel, R, SAS, SPSS. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II
Test for normality; Testing of hypothesis using chi-square, t and F statistics and Z-test.

UNIT III
Data preparation for ANOVA and ANCOVA, Factorial Experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

UNIT IV
Analysis of mixed models; Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

UNIT V
Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

Practical
• Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data;
• Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, one-way analysis of variance;
• Designs for Factorial Experiments, fixed effect models, random effect models, mixed effect models, estimation of variance components;
• Linear regression, Multiple regression, Regression plots;
• Discriminant analysis - fitting of discriminant functions, identification of important variables;
• Factor analysis. Principal component analysis - obtaining principal component.

Suggested Reading
Anderson C.W. and Loynes R.M. 1987. The Teaching of Practical Statistics. John Wiley.
Atkinson A.C. 1985. Plots Transformations and Regression. Oxford University Press.

Chambers J.M., Cleveland W.S., Kleiner B and Tukey P.A. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmount, California.
Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall. Chatfield C. 1995. Problem Solving: A Statistician's Guide. Chapman & Hall.
Cleveland W.S. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California.
Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.
Erickson B.H. and Nosanchuk T.A. 1992. Understanding Data. 2nd Ed. Open University Press, Milton Keynes.
Snell E.J. and Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman and Hall.
Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.
Tufte ER. 1983. The Visual Display of Quantitative Information. Graphics Press, Cheshire, Conn.
Velleman PF and Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.
Weisberg S. 1985. Applied Linear Regression. John Wiley.
Wetherill GB. 1982. Elementary Statistical Methods. Chapman & Hall.

COMMON COURSES

Course Code: PGSS 0501
Credit Hours: 0+1
Course Title: Library and Information Services

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

Course outcomes: The students will be acquainted with basics of library information.

Practical

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

Course Code: PGSS 0502
Credit Hours: 0+1
Course Title: Technical Writing and Communications Skills

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

Course outcomes: The students will be acquainted with basics of Scientific writings, writing techniques and improve their communication skills.

Practical

- 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
- Iillustrations, 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 Reading

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
Collins' Cobuild English Dictionary. 1995.
Harper Collins. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed.
Holt, Rinehart & 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.
Barnes & Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.
Abhishek. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed.

Prentice Hall of India.
Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

Course Code: PGSS 0503
Credit Hours: 1+0
Course Title: Intellectual Property and its Management in Agriculture

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

Course outcomes: This course will provide knowledge to students about Protection of Intellectual Properties.

Theory
Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Reading
Erbisch FH & 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 & Aesthetic Technologies.
Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
Rothschild M & 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; National Biological Diversity Act, 2003.

Course Code: PGSS 0504

Credit Hours: 0+1
Course Title: Basic Concepts in Laboratory Techniques

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

Course outcomes: The students will be well versed with basic laboratory techniques and precautions.

Practical

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

Suggested Reading

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

Course Code: PGSS 0505
Credit Hours: 1+0
Course Title: Agricultural Research, Research Ethics and Rural Development Programmes

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

Course outcomes: The students will be acquainted with knowledge about Research Ethics and development programmes in rural areas.

Theory

UNIT I

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

UNIT II

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

UNIT III

Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Reading

Bhalla GS & 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.