

Restructured and Revised  
Syllabi of Post-graduate Programmes

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# Horticultural Sciences

## Vegetable Science



## Course Title with Credit Load M.Sc. (Hort.) in Vegetable Science

Course Code	Course Title	Credit Hours
	Major Courses (20 Credits)	
VSC 501*	Production of Cool Season Vegetable Crops	2+1
VSC 502*	Production of Warm Season Vegetable Crops	2+1
VSC 503*	Growth and Development of Vegetable Crops	2+1
VSC 504*	Principles of Vegetable Breeding	2+1
VSC 505	Breeding of Self Pollinated Vegetable Crops	2+1
VSC 506	Breeding of Cross Pollinated Vegetable Crops	2+1
VSC 507	Protected Cultivation of Vegetable Crops	2+1
VSC 508	Seed Production of Vegetable Crops	2+1
VSC 509	Production of Underutilized Vegetable Crops	2+1
VSC 510	Systematics of Vegetable Crops	1+1
VSC 511	Organic Vegetable Production	1+1
VSC 512	Production of Spice Crops	2+1
VSC 513	Processing of Vegetable	1+1
VSC 514	Postharvest Management of Vegetable Crops	2+1
	Minor Courses	08
	Supporting Courses	06
	Common compulsory courses	05
VSC 591	Seminar	0+1
VSC 599	Research	0+30
	<b>Total Credits</b>	<b>70</b>

\*Compulsory among major courses

## Course Contents

### M.Sc. (Hort.) in Vegetable Science

**Course Title : Production of Cool Season Vegetable Crops**

**Course Code : VSC 501**

#### **Theory**

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

#### **I. 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.
- Chadha KL. (Ed.). 2002. *Hand book of horticulture*. ICAR.
- Chauhan DVS. (Ed.). 1986. *Vegetable production in India*. Ram prasad and sons.
- Fageria MS, Choudhary BR and Dhaka RS. 2000. *Vegetable crops: production technology*. Vol. II. Kalyani publishers.
- Gopalakrishnan 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*. 2<sup>nd</sup> 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 Title : Production of Warm Season Vegetable Crops**

**Course Code : VSC 502**

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

### **Theory**

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/ hybrids, seed rate and seed treatment, raising of nursery including grafting technique, sowing/ planting time and methods, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices namely hydroponics, aeroponics, weed control, mulching, role of plant growth regulators, physiological disorders, maturity indices, harvesting, yield, post-harvest management (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.
- 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*. 2<sup>nd</sup>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.
- 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 Title** : **Growth and Development of Vegetable Crops**

**Course Code** : **VSC 503**

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

## **Theory**

### **Unit I**

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

### **Unit II**

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

### **Unit III**

*Abiotic factors*—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* (2<sup>nd</sup> Edition) MacMillan.
- Gupta US. Eds. 1978. *Crop physiology*. Oxford and IBH, New Delhi.
- Kaloo 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 Title** : **Principles of Vegetable Breeding**  
**Course Code** : **VSC 504**  
**Credit Hours** : **(2+1)**

### **Theory**

#### **Unit I**

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

#### **Unit II**

*Selection procedures*- Techniques of selfing and crossing; Breeding systems and methods; Selection procedures and hybridization; Genetic architecture; Breeding for biotic 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 KV and 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 Title** : **Breeding of Self Pollinated Vegetable Crops**  
**Course Code** : **VSC 505**  
**Credit Hours** : **(2+1)**

## **Theory**

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

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

Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.

Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. *Plant Breeding-principles and prospects*. Chapman and Hall.

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

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

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

Kumar JC and Dhaliwal MS. 1990. *Techniques of developing hybrids in vegetable crops*. Agro Botanical Publ.

Paroda RS and Kaloo 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.
- Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume III. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
- Rai N and Rai M. 2006. *Heterosis breeding in vegetable crops*. New India Publ. Agency.
- Ram 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 Title : Breeding of Cross Pollinated Vegetable Crops**

**Course Code : VSC 506**

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

### **Theory**

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

### **Unit I**

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

### **Unit II**

*Cole crops*—Cauliflower, cabbage, 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.
- Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.
- Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.
- Hayward MD, Bosemark NO and Romagosa I. (Eds.), 1993. *Plant breeding-principles and prospects*. Chapman and Hall.
- 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
- Kaloo G. 1988. *Vegetable breeding*. Vols. I-III. CRC Press.
- Kaloo G. 1998. *Vegetable breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
- Kumar JC and Dhaliwal MS. 1990. *Techniques of developing hybrids in vegetable crops*. Agro botanical publ.
- Paroda RS and Kaloo 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 and III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
- Prohens J and Nuez F. 2007. *Handbook of Plant Breeding- Vegetables* (Vol I and II), Springer, USA.
- 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 Title : Protected Cultivation of Vegetable Crops**

**Course Code : VSC 507**

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

### Theory

#### Unit I

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

#### Unit II

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

#### Unit III

*Abiotic factors-* Effect of environmental factors and manipulation of temperature,

light, carbon dioxide, humidity, etc. on growth and yield of different vegetables.

#### **Unit IV**

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

#### **Unit V**

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

#### **Unit VI**

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

#### **Practical**

- 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.
- Kaloo 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*. 2<sup>nd</sup> Ed. Agrobios.
- Resh HM. 2012. *Hydroponic food production*. 7<sup>th</sup> Edn. 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* (1<sup>st</sup> 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 Title : Seed Production of Vegetable Crops**

**Course Code : VSC 508**

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

#### **Theory**

##### **Unit I**

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

Status and share of vegetable seeds in seed industry

### **Unit II**

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

### **Unit III**

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

### **Unit IV**

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

### **Unit V**

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

## **II. 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**

- Agarwal 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* (2<sup>nd</sup> Edition). CAB International.
- Kaloo 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 Title : Production of Underutilized Vegetable Crops**

**Course Code : VSC 509**

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

### **Theory**

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

#### **Unit I**

*Stem and bulb crops*—Asparagus, leek and chinese chive

#### **Unit II**

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

#### **Unit III**

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

#### **Unit IV**

*Gourds and melons*—Sweet gourd, spine gourd, 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;
- Visit to local farms.

### **Suggested Reading**

- Bhat KL. 2001. *Minor vegetables-untapped potential*. Kalyani publishers, New Delhi.
- Indira P and Peter KV. 1984. *Unexploited tropical vegetables*. Kerala agricultural university, Kerala.
- Pandey AK. 2011. *Aquatic vegetables*. Agrotech publisher academy, New Delhi.
- Peter KV. (Eds.). 2007-08. *Underutilized and underexploited horticultural crops*. Vol.1-4, New India publishing agency, Lucknow.
- Peter KV and Hazra P. (Eds.). 2012. *Hand book of vegetables*. Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.

Peter KV and Hazra P. (Eds). 2015. *Hand book of vegetables* Volume II and III. Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.  
Rana MK. 2018. *Vegetable crop science*. CRC Press Taylor and Francis Group 6000 Broken Sound Parkway NW, Suite 300 Boca Raton, FL 33487-2742 ISBN: 978-1-1380-3521-8  
Rubatzky VE and Yamaguchi M. 1997. *World vegetables: vegetable crops*. NBPGR, New Delhi.

**Course Title** : **Systematics of Vegetable Crops**  
**Course Code** : **VSC 510**  
**Credit Hours** : **(1+1)**

## **Theory**

### **Unit I**

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

### **Unit II**

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

### **Unit III**

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

### **Unit IV**

*Cytology*—Cytological level of various vegetable crops with descriptive keys

### **Unit V**

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

## **Practical**

- 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.

## **II. 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 Title : Organic Vegetable Production**

**Course Code : VSC 511**

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

### **Theory**

#### **Unit I**

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

#### **Unit II**

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

#### **Unit III**

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

#### **Unit IV**

*Composting methods*—Indigenous methods of composting, Panchyagavya, 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.

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

**Course Code : VSC 512**

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

### **Theory**

Introduction and importance of spice crops- historical accent, present status (national

and international), future prospects, botany and taxonomy, climatic and soil requirement, commercial cultivars/ hybrids, site selection, layout, sowing/ planting time and methods, seed rate and seed treatment, nutritional and irrigation requirement, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, 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.

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

**Course Title : Processing of Vegetable Crops**

**Course Code : VSC 513**

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

### **Theory**

#### **Unit I**

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

#### **Unit II**

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

#### **Unit III**

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

#### **Unit IV**

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

#### **Unit V**

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

### **Practical**

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

### **Suggested 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*. 2<sup>nd</sup> 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*. 4<sup>th</sup> 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.
- Hildegard 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*. 2<sup>nd</sup> 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*. 3<sup>rd</sup> Ed. International Book Distri. Co.
- Tressler and Joslyn MA. 1971. *Fruit and vegetable juice processing technology*. AVI Publ. Co.
- Verma LR and Joshi VK. 2000. *Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management*. Indus Publ. Co.

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

**Course Code : VSC 514**

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

### **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*. Gene-Tech books, New Delhi.
- Haid NF and Salunkhe SK. 1997. *Postharvest physiology and handling of fruits and vegetables*. Grenada Publ.
- Mitra SK. 1997. *Postharvest physiology and storage of tropical and sub-tropical fruits*. CABI.
- Paliyath G, Murr DP, Handa AK and Lurie S. 2008. *Postharvest biology and technology of Fruits, vegetables and flowers*. Wiley-Blackwell, ISBN: 9780813804088.
- Ranganna S. 1997. *Handbook of analysis and quality control for fruit and vegetable products*. Tata McGraw-Hill.
- Stawley JK. 1998. *Postharvest physiology of perishable plant products*. CBS publishers.
- Sudheer KP and Indira V. 2007. *Postharvest technology of horticultural crops*. New India Publ. Agency.
- 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.

## **Course Title with Credit Load Ph.D. (Hort.) in Vegetable Science**

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

\*Compulsory among major courses

# **Course Contents**

## **Ph.D. (Hort.) in Vegetable Science**

**Course Title** : **Recent Trends in Vegetable Production**

**Course Code** : **VSC 601**

**Credit Hours** : **(3+0)**

### **Theory**

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

### **Unit I**

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

### **Unit II**

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

### **Unit III**

Okra, onion, peas and beans, amaranth and drumstick.

### **Unit IV**

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

## **Unit V**

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

### **Suggested Reading**

- Bose TK and Som NG. 1986. *Vegetable crops of India*. Naya prokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA and Som MG. 2003. *Vegetable crops*. Vols. I-III. Naya Udyog.
- Brewster JL. 1994. *Onions and other vegetable alliums*. CABI.
- 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.
- FFTC. *Improved vegetable production in Asia*. Book Series No. 36.
- Ghosh SP, Ramanujam T, Jos JS, Moorthy SN and Nair RG. 1988. *Tuber crops*. Oxford and IBH.
- Gopalakrishanan TR. 2007. *Vegetable crops*. New India Publ. Agency.
- Hazra P and Som MG. 2015. *Seed production and hybrid technology of vegetable crops*. Kalyani publishers, Ludhiana.
- Hazra P. 2016. *Vegetable science*. 2<sup>nd</sup>edn, Kalyani publishers, Ludhiana.
- Hazra P. 2019. *Vegetable production and technology*. New India publishing agency, New Delhi.
- Kallo G and Singh K. (Ed.). 2001. *Emerging scenario in vegetable research and development*. Research periodicals and Book Publ. House.
- Kurup GT, Palanisami MS, Potty VP, Padmaja G, Kabeerathuma S and Pallai SV. 1996. *Tropical tuber crops, problems, prospects and future strategies*. Oxford and IBH.
- Rana MK. 2008. *Olericulture in India*. Kalyani Publishers, New Delhi.
- Rana MK. 2008. *Scientific cultivation of vegetables*. Kalyani Publishers, New Delhi.
- 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.
- Sin MT and Onwueme IC. 1978. *The tropical tuber crops*. John Wiley and Sons.
- Singh DK. 2007. *Modern vegetable varieties and production technology*. International book distributing Co.
- Singh NP, Bhardwaj AK, Kumar A and Singh KM. 2004. *Modern technology on Vegetable production*. International book distr. Co.
- Singh PK, Dasgupta SK and Tripathi SK. 2006. *Hybrid vegetable development*. International book distr. 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 Title : Advances in Breeding of Vegetable Crops**

**Course Code : VSC 602**

**Credit Hours : (3 +0)**

### **III. Theory**

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

## **Unit I**

*Solanaceous crops*—Tomato, Brinjal, Hot Peeper, Sweet Pepper, Okra and Potato

## **Unit II**

Cucurbits and Cole crops

## **Unit III**

*Legumes and leafy vegetables*—Peas and Beans, Amaranth, Palak, Chenopods and Lettuce.

## **Unit IV**

*Root crops and onion*—Carrot, Beetroot, Radish, Turnip, Onion

## **Unit V**

*Tuber crops*—Sweet potato, Tapioca, Elephant foot yam, Colocasia, Dioscorea

## **Suggested Reading**

- Allard RW. 1999. *Principle of plant breeding*. John Willey and Sons, USA.
- 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.
- Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.
- Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.
- Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. *Plant Breeding-principles and prospects*. Chapman and Hall.
- 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
- Kaloo G. 1988. *Vegetable breeding* (Vol. I, II, III). CRC Press, FL, USA.
- Kaloo 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 Kaloo 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, 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.
- 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 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 Title : Abiotic Stress Management in Vegetable Crops**

**Course Code : VSC 603**

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

**Theory**

## **Unit I**

*Environmental stress*—its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stress.

## **Unit II**

*Mechanism and measurements*—tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops.

## **Unit III**

*Soil-plant-water relations*—under different stress conditions in vegetable crops production and their management practices.

## **Unit IV**

Techniques of vegetable growing under water deficit, water logging, salinity and sodicity.

## **Unit V**

Use of chemicals—techniques of vegetable growing under high and low temperature conditions, use of chemicals and antitranspirants in alleviation of different stresses.

## **Practical**

- Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops;
- Measurement of tolerance to various stresses in vegetable crops;
- Short term experiments on growing vegetable under water deficit, water logging, salinity and sodicity, high and low temperature conditions;
- Use of chemicals for alleviation of different stresses.

## **Suggested Reading**

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

Dwivedi P and Dwivedi RS. 2005. *Physiology of abiotic stress in plants*. Agrobios.

Janick JJ. 1986. *Horticultural science*. 4th Ed. WH Freeman and Co.

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

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

Lerner HR. (Eds.). 1999. *Plant responses to environmental stresses*. Marcel Decker.

Maloo SR. 2003. *Abiotic stresses and crop productivity*. Agrotech Publ. Academy.

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

Peter KV and Pradeep Kumar T. 2008. *Genetics and breeding of vegetables*. (Revised Ed.). ICAR.

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.

Ram HH. 2001. *Vegetable breeding*. Kalyani.

Rao NK. (Eds.). 2016. *Abiotic stress physiology of horticultural crops*. Springer publication.



**Course Title** : **Seed Certification, Processing and Storage of Vegetable Seeds**

**Course Code** : **VSC 604**

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

### **Theory**

#### **Unit I**

Seed certification, history, concepts and objectives, seed certification agency, phases of seed certification, Indian Minimum seed Certification standards, Planning and management of seed certification programmes. Problems of vegetable seed production and their remedial measures

#### **Unit II**

Principles and procedures of field inspection, seed sampling, testing and granting certification, OECD certification Schemes.

#### **Unit III**

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

#### **Unit IV**

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

#### **Unit V**

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

### **Practical**

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

### **Suggested Reading**

Agarwal PK and Anuradha V. 2018. *Fundamentals of seed science and technology*. Brilliant publications, New Delhi.

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.

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 Choudhry AK. 2000. *Vegetable crops: breeding and seed production* Vol 1. Kalyani publishers, New Delhi.

George RAT. 1999. *Vegetable seed production* (2<sup>nd</sup> Edition). CAB International.

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

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

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

**Course Title** : **Breeding for Special Traits in Vegetable Crops**  
**Course Code** : **VSC 605**  
**Credit Hours** : **(2+0)**

### **Theory**

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

### **Unit I**

Brassica group, carrot and beetroot.

### **Unit II**

Tomato, brinjal, peppers and potato.

### **Unit III**

Green leafy vegetables, Legume crops and okra.

### **Unit IV**

Cucurbitaceous vegetable crops and edible Alliums.

### **Unit V**

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

### **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.
- Gardner EJ. 1975. *Principles of genetics*. John Wiley and Sons.
- Hayes HK, Immer FR and Smith DC. 1955. *Methods of plant breeding*. McGraw-Hill.
- Hayward MD, Bosemark NO and Romagosa I. (Eds.). 1993. *Plant Breeding-principles and prospects*. Chapman and Hall.
- Hazra P and Som MG. 2015. *Vegetable science* (Second revised edition), Kalyani publishers, Ludhiana, 598p.
- Kaloo G. 1988. *Vegetable breeding*. Vols. I-III. CRC Press.
- Kaloo G. 1998. *Vegetable breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
- Kumar JC and Dhaliwal MS. 1990. *Techniques of developing hybrids in vegetable crops*. Agro Botanical Publ.
- Paroda RS and Kaloo 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, 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.
- 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.
- Rout GR and Peter KV. 2008. *Genetic engineering of horticultural crops*. Academic press, Elsevier,

USA

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 Title : Biodiversity and Conservation of Vegetable Crops**  
**Course Code : VSC 606**  
**Credit Hours : (2+1)**

## **Theory**

### **Unit I**

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

### **Unit II**

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

### **Unit III**

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

## **Practical**

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

## **Suggested Reading**

Dhillon BS, Tyagi RK, Lal A and Saxena S. 2004. *Plant genetic resource management. – horticultural crops*. Narosa publishing house, New Delhi.  
Engles JM, Ramanath RV, Brown AHD and Jackson MT. 2002. *Managing plant genetic resources*, CABI, Wallingford, UK.  
Hancock J. 2012. *Plant evolution and the origin of crops species*. CAB International.  
Jackson M, Ford-Lloyd B and Parry M. 2014, *Plant genetic resources and climate change*. CABI, Wallingford, UK  
Moore JN and Ballington JR. 1991. *Genetic resources of temperate Fruit and nut crops*. ISHS,

- Belgium.
- Peter KV. 2008. *Biodiversity of horticultural crops*. Vol. II. Daya Publ. House, Delhi.
- Peter KV. 2011. *Biodiversity in horticultural crops*. Vol.III. Daya Publ. House, Delhi.
- Rajasekharan PE, Rao V and Ramanatha V. 2019. *Conservation and utilization of horticultural genetic resources*. Springer.
- Rana JC and Verma VD. 2011. *Genetic resources of temperate minor fruits (indigenous and exotic)*. NBPGR, New Delhi.
- Sthapit *et al.* 2016. *Tropical fruit tree diversity (good practices for in situ and ex situ conservation)*. Bioversity international. routledge, Taylor and Francis Group.
- Virchow D. 2012. *Conservation of genetic resources*, Springer Verlag, Berlin

**Course Title : Biotechnological Approaches in Vegetable Crops**

**Course Code : VSC 607**

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

### **Theory**

#### **Unit I**

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

#### **Unit II**

*Somatic embryogenesis – somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion. Somatic hybrids and cybrids and their application in vegetable improvement programme.*

#### **Unit III**

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

#### **Unit IV**

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

#### **Unit V**

*Concepts and methods of next generation sequencing (NGS)- Genome sequencing, transcriptomics, proteomics, metabolomics. Genome editing (ZFN, TALENS and CRISPER)*

### **Crops**

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

### **Practical**

- Micropropagation, Pollen- Ovule and Embryo culture- Synthetic seed production (2);
- *In-vitro* mutation induction, *in-vitro* rooting – hardening at primary and secondary nurseries (3);
- DNA isolation from economic vegetable crop varieties – Quantification and amplification (2);
- DNA and Protein profiling – molecular markers, PCR Handling (2);
- Vectors for cloning and particle bombardment (3);
- DNA fingerprinting of flower crop varieties (3);

- Project preparation for establishment of low, medium and high cost tissue culture laboratories (1).

### **Suggested Reading**

- Bajaj YPS. (Ed.). 1987. *Biotechnology in agriculture and forestry*. Vol. XIX. Hitech and Micropropagation. Springer.
- Chadha KL, Ravindran PN and Sahijram L. (Eds.). 2000. *Biotechnology of horticulture and plantation crops*. Malhotra Publ. House.
- Debnath M. 2005. *Tools and techniques of biotechnology*. Pointer publication, New Delhi.
- Gorden H and Rubsell S. 1960. *Hormones and cell culture*. AB Book Publ.
- Keshavachandran R. 2007. *Recent trends in biotechnology of horticultural crops*. New India Publ. Agency.
- Keshavachandran R and Peter KV. 2008. *Plant biotechnology; tissue culture and gene transfer*. Orient and Longman, USA.
- Keshavachandran R. 2007. *Recent trends in biotechnology of horticultural crops*. New-India Publication Agency, New Delhi.
- Panopoulos NJ. (Ed.). 1981. *Genetic engineering in plant sciences*. Praeger Publ.
- Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK and Mohanadas S. 2001. *Biotechnology of horticultural crops*. Vols. I-III. Naya Prokash.
- Pierik RLM. 1987. *In-vitro culture of higher plants*. Martinus Nijhoff Publ.
- Prasad S. 1999. *Impact of plant biotechnology on horticulture*. 2nd Ed. Agro Botanica.
- Rout GR and Peter KV. 2018. *Genetic engineering of horticultural crops*. Academic Press Elsevier, USA.
- Sharma R. 2000. *Plant tissue culture*. Campus Books.
- Singh BD. 2010. *Biotechnology- expanding horizons*. Kalyani Publishers, New Delhi.
- Skoog Y and Miller CO. 1957. *Chemical regulation of growth and formation in plant tissue cultured in-vitro*. Attidel. II Symp. On biotechnology action of growth substance.
- Vasil TK, Vasi M, While DNR and Bery HR. 1979. *Somatic hybridization and genetic manipulation in plants, plant regulation and world agriculture*. Planum Press.

**Course Title : Advanced Laboratory Techniques for Vegetable Crops**

**Course Code : VSC 608**

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

### **Theory**

#### **Unit I**

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

#### **Unit II**

*Destructive and non-destructive analysis methods* – Refractometry, spectrophotometry, non-destructive determination of colour, ascorbic acid, sugars, and starch in food crops.

#### **Unit III**

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

#### **Unit IV**

*Sensory analysis* – Importance of ethylene, quantitative estimation of rate of ethylene

evolution, using gas chromatograph (GC). Sensory analysis techniques, control of test rooms, products and panel.

### **Practical**

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

### **Suggested Reading**

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

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

Linskens HF and Jackson JF. 1995. *Fruit analysis*. Springer.

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

Pomrenz Y and Meloan CE. 1996. *Food analysis – theory and practice*. CBS, USA.

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

Thompson AK. 1995, *Postharvest technology of fruits and vegetables*. Blackwell sciences. USA.

## Selected Journals

Sr. No.	Name of the Journal	ISSN No.
1.	<i>American Journal of Horticultural Sciences</i>	0003-1062
2.	<i>American Potato Growers</i>	
3.	<i>American Scientist</i>	1545-2786
4.	<i>Annals of Agricultural Research</i>	9703179
5.	<i>Annual Review of Plant Physiology</i>	0066-4294
6.	<i>California Agriculture</i>	1097-0967
7.	<i>Haryana Journal of Horticultural Sciences</i>	0970-2873
8.	<i>HAU Journal of Research</i>	0379-4008
9.	<i>Horticulture Research</i>	2052-7276
10.	<i>HortScience</i>	2327-9834
11.	<i>IIVR Bulletins</i>	1462-0316
12.	<i>Indian Horticulture</i>	0019-4875
13.	<i>Indian Journal of Agricultural Sciences</i>	0019-5022
14.	<i>Indian Journal of Horticulture</i>	0974-0112
15.	<i>Indian Journal of Plant Physiology</i>	2662-2548
16.	<i>Journal of American Society for Horticultural Sciences</i>	0003-1062
17.	<i>Journal of Arecanut and Spice Crops</i>	
18.	<i>Journal of Food Science and Technology</i>	0975-8402
19.	<i>Journal of Plant Physiology</i>	0176-1617
20.	<i>Journal of Biology and Technology</i>	0925-5214
21.	<i>Postharvest Biology and Technology</i>	0925-5214
22.	<i>Scientia Horticulturae</i>	0304-4238
23.	<i>Seed Research</i>	2151-6146
24.	<i>Seed Science</i>	23171537
25.	<i>South Indian Horticulture</i>	0038-3473
26.	<i>Vegetable Grower</i>	2330-2321
27.	<i>Vegetable Science</i>	2455-7552