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

### Major courses

| Course Code | Course Title | Credit hrs |
|---|---|---|
| | **Semester I** | |
| VSC-511* | Production of Cool Season Vegetable Crops | 2+1 |
| VSC-512* | Growth and Development of Vegetable Crops | 2+1 |
| VSC-513* | Principles of Vegetable Breeding | 2+1 |
| VSC-514 | Breeding of Self Pollinated Vegetable Crops | 2+1 |
| VSC-515 | Systematics of Vegetable Crops | 1+1 |
| | **Semester II** | |
| VSC-521* | Production of Warm Season Vegetable Crops | 2+1 |
| VSC-522 | Seed Production of Vegetable Crops | 2+1 |
| VSC-523 | Production of Spice Crops | 2+1 |
| VSC-524 | Breeding of Cross Pollinated Vegetable Crops | 2+1 |
| VSC-525 | Production of Underutilized Vegetable Crops | 2+1 |
| | **Semester III** | |
| VSC-531 | Protected Cultivation of Vegetable Crops | 2+1 |
| VSC-532 | Organic Vegetable Production | 1+1 |
| VSC-533 | Processing of Vegetable | 1+1 |
| VSC-534 | Postharvest Management of Vegetable Crops | 2+1 |
| VSC-591 | Seminar | 1+0 |
| | **Semester IV** | |
| VSC -500 | Research | 0+30 |

*** Core and compulsory courses.**

**Note:** A student has to opt total 20 credit hours.

### Syllabus of Major courses of Vegetable Science

**VSC-511 PRODUCTION OF COOL SEASON VEGETABLE CROPS (2+1)**

**THEORY**

Introduction, commercial and nutritional importance, origin and distribution, botany and taxonomy, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/hybrids, seed rate and seed treatment, raising of nursery, sowing/planting time and methods, 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

**RESOURCES**


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

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

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

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

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

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

Gopalakrishanan, T.R., 2007, Vegetable crops. New India publ. agency.

Hazra, P. and Banerjee M.K. and Chattopadhyay, A., 2012, Varieties of vegetable crops in India, (Second edition), Kalyani publishers, Ludhiana , 199

Hazra, P., 2016, Vegetable science. 2nd edn, Kalyani publishers, Ludhiana.

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

Hazra, P., Chattopadhyay, A., Karmakar K. and Dutta, S., 2011, Modern technology for vegetable production, New India publishing agency, New Delhi, 413p

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

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

Rana, M.K., 2014, Technology for vegetable production. Kalyani publishers, New Delhi.

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

Saini, G.S., 2001, A text book of oleri and flori culture. Aman publishing house.

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

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

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

Singh, S.P. (Ed.), 1989, Production technology of vegetable crops. Agril. comm. res. centre.

Thamburaj, S. and Singh, N. (Eds.), 2004, Vegetables, tuber crops and spices. ICAR. Thompson, H.C. and Kelly, W.C. (Eds.), 1978, Vegetable crops. Tata McGraw-Hill.


## VSC-512 GROWTH AND DEVELOPMENT OF VEGETABLE CROPS (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, 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

**RESOURCES**

Bleasdale, J.K.A., 1984, Plant physiology in relation to horticulture (2nd Edition) MacMillan. Gupta, U.S., Eds., 1978, Crop physiology. Oxford and IBH, New Delhi.

Kalloo, G. 2017. Vegetable grafting: Principles and practices. CAB International Krishnamoorti, H.N., 1981, Application growth substances and their uses in agriculture. Tata McGraw Hill, New Delhi.

Leopold, A.C. and Kriedemann, P. E., 1981, Plant growth and development, Tata McGraw- Hill, New Delhi.

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

Peter, K.V., (Eds), 2008, Basics of horticulture. New India publication agency, New Delhi. Rana, M.K., 2011. *Physio-biochemistry and Biotechnology of Vegetables*. New India Publishing Agency, Pritam Pura, New Delhi.

Saini *et al.* (Eds.), 2001, Laboratory manual of analytical techniques in horticulture. Agrobios, Jodhpur.

Wien, H.C. (Eds.), 1997, The physiology of vegetable crops. CAB International.

## VSC-513 PRINCIPLES OF VEGETABLE BREEDING (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**

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

**RESOURCES**

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

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

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

Peter, K.V. 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, B.D., 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.

## VSC-514 BREEDING OF SELF POLLINATED VEGETABLE CROPS (2+1)

**THEORY**

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

**RESOURCES**

Allard, R.W., 1999, Principles of plant breeding. John Wiley and Sons. Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.

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

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

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

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

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

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

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

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

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

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

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

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

Peter, K.V. and Hazra, P. (Eds), 2015,Hand book of vegetables Volume III.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
Rai, N. and Rai, M., 2006, Heterosis breeding in vegetable crops. New India Publ. Agency. Ram, H.H., 1998, Vegetable breeding: principles and practices. Kalyani Publ.
Simmonds, N.W., 1978, Principles of crop improvement. Longman. Singh BD. 1983. Plant Breeding. Kalyani Publ.
Singh, P.K., Dasgupta, S.K. and Tripathi, S.K., 2004, Hybrid vegetable development. International Book Distributing Co.
Swarup, V., 1976, Breeding procedure for cross-pollinated vegetable crops. ICAR.

## VSC-515 SYSTEMATICS OF VEGETABLE CROPS (1+1)

**THEORY**

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

UNIT II: *Origin and evolution*- Origin, history, evolution and distribution of vegetable crops UNIT III: *Botanical and morphological description*- Botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables; Morphological keys to identify important families, floral biology, floral formula and diagram; Morphological description of all parts of vegetables

UNIT IV: *Cytology*- Cytological level of various vegetable crops with descriptive keys

UNIT V: *Molecular markers*- Importance of molecular markers in evolution of vegetable crops; Molecular markers as an aid in characterization and taxonomy of vegetable crops

**PRACTICAL**

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

**RESOURCES**

Chopra, G.L., 1968, Angiosperms- systematics and life cycle. S. Nagin Dutta, A.C., 1986, A class book of botany. Oxford Univ. Press.
Pandey, B.P., 1999, Taxonomy of angiosperm. S. Chand and Co
Peter, K.V. and Pradeepkumar, T., 2008, Genetics and breeding of vegetables. (Revised), ICAR.
Peter, K.V. and Hazra, P. (Eds), 2012,Hand book of vegetables.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p.
Peter, K.V. and Hazra, P. (Eds), 2015,Hand book of vegetables Volume II.Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 509 p.
Peter, K.V. and Hazra, P. (Eds), 2015,Hand book of vegetables Volume III.Studium press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 634 p.
Simmonds, N.W. and Smartt, J., 1995, Evolution of crop plants. Wiley-Blackwell. Soule, J., 1985, Glossary for Horticultural Crops. John Wiley and Sons.
Srivastava, U., Mahajan, R.K., Gangopadyay, K.K., Singh, M. and Dhillon, B.S., 2001, Minimal descriptors of agri-horticultural crops. Part-II: Vegetable Crops. NBPGR, New Delhi.
Vasistha, 1998, Taxonomy of angiosperm. KalyaniPubl.
Vincent, E.R. and Yamaguchi, M., 1997, World vegetables. 2nd Ed. Chapman and Hall.

## VSC-521 PRODUCTION OF WARM SEASON VEGETABLE CROPS (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

**RESOURCES**


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

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

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

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

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

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

Gopalakrishanan, T.R., 2007, Vegetable crops. New India publ. agency.

Hazra, P. and Banerjee, M. K. and Chattopadhyay, A. (2012), Varieties of vegetable crops in India, (Second edition), Kalyani publishers, Ludhiana , 199 p

Hazra, P., 2016, Vegetable science. 2nd edn, Kalyani publishers, Ludhiana.

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

Hazra, P., Chattopadhyay, A., Karmakar, K. and Dutta, S., (2011),Modern technology for vegetable production, New India publishing agency, New Delhi, 413p

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

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

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

Saini, G.S., 2001, A text book of oleri and flori culture. Aman publishing house.

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

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

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

Singh, S.P. (Ed.), 1989, Production technology of vegetable crops. Agril. comm. res. centre. Thamburaj, S. and Singh, N. (Eds.), 2004, Vegetables, tuber crops and spices. ICAR. Thompson, H.C. and Kelly, W.C. (Eds.), 1978, Vegetable crops. Tata McGraw-Hill.


**VSC-522 SEED PRODUCTION OF VEGETABLE CROPS (2+1)**

**THEORY**

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

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

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

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

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

**PRACTICAL**

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

**RESOURCES**


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

Agrawal, P.K. and Dadlani M. (Eds.), 1992, Techniques in seed science and technology. South Asian Publ.

Agrawal, R.L. (Ed.), 1997, Seed technology. Oxford and IBH.

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

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

Bendell, P.E. (Eds.), 1998, Seed science and technology: Indian forestry species. Allied Publ.

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

Copland, L.O. and McDonald, M.B., 2004, Seed science and technology, Kluwer Academic Press.

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

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

Hazra, P. and Som, H.G. 2015, Seed production and hybrid technology of vegetable crops. Kalyani publishers, Ludhiana.

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

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

More, T.A., Kale, P.B. and Khule, B.W., 1996, Vegetable seed production technology. Maharashtra state seed corp.

Rajan, S. and Markose, B. L., 2007, Propagation of horticultural crops. New India publ. agency.

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

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

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

## VSC-523 PRODUCTION OF SPICE CROPS (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

**RESOURCES**

Agarwal, S., Sastry, E.V.D. and Sharma, R.K., 2001, Seed spices: production, quality, export. Pointer Publication.

Arya, P.S., 2003, Spice crops of India. Kalyani.

Bhattacharjee, S.K., 2000, Hand book of aromatic plants. Pointer publications.

Bose, T.K., Mitra, S.K., Farooqi, S.K. and Sadhu, M.K. (Eds.), 1999, Tropical horticulture.Vol.I. Naya Prokash.

Chadha, K.L. and Rethinam, P. (Eds.), 1993, Advances in horticulture. Vols. IX-X. Plantation crops and spices. Malhotra Publ. House.

Gupta, S. (Ed.), Hand book of spices and packaging with formulae. engineers India research institute, New Delhi.

Kumar, N.A., Khader, P., Rangaswami and Irulappan, I., 2000, Introduction to spices, plantation crops, medicinal and aromatic plants. Oxford and IBH.

Nybe, E.V., Miniraj, N. and Peter, K.V., 2007, Spices. New India Publ. Agency. Parthasarthy, V.A., Kandiannan ,V. and Srinivasan, V., 2008, Organic spices. New India Publ. Agency.

Peter, K.V., 2001, Hand book of herbs and spices. Vols. I-III. Woodhead Publ. Co. UK and CRC USA

Pruthi, J.S. (Ed.), 1998, Spices and condiments. National Book Trust

Pruthi, J.S., 2001, Minor spices and condiments- crop management and post harvest technology. ICAR.

Purseglove, J.W., Brown, E.G., Green, C.L. and Robbins, S.R.J. (Eds.), 1981, Spices. Vols. I, Longman.

Shanmugavelu, K.G., Kumar, N. and Peter, K.V., 2002, Production technology of spices and plantation crops. Agrobios.

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

Tiwari, R.S. and Agarwal, A., 2004, Production technology of spices. International Book Distr. Co.

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

## VSC-524 BREEDING OF CROSS-POLLINATED VEGETABLE CROPS (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

**RESOURCES**


Allard, R.W., 1999, Principles of plant breeding. John Wiley and Sons. Basset, M.J. (Ed.), 1986, Breeding vegetable crops. AVI Publ.

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

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

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

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

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

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

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

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, J.C. and Dhaliwal, M.S., 1990, Techniques of developing hybrids in vegetable crops. Agro botanical publ.

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

Peter, K.V. and Pradeepkumar, T., 2008, Genetics and breeding of vegetables.revised, ICAR. Peter, K.V. and Hazra, P. (Eds), 2012,Hand book of vegetables.Studium Press LLC, P.O. Box 722200, Houston, Texas 77072, USA, 678p

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

Rai, N. and Rai, M., 2006, Heterosis breeding in vegetable crops. New India Publ. Agency. Prohens, J. and Nuez, F. 2007. Handbook of Plant Breeding- Vegetables (Vol I and II), Springer, USA.

Ram, H.H., 1998, Vegetable breeding: principles and practices. Kalyani Publ. Simmonds, N.W., 1978, Principles of crop improvement. Longman.

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

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

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

## VSC-525 PRODUCTION OF UNDERUTILIZED VEGETABLE CROPS (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 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 III: *Leafy vegetables*- Celery, parsley, indian spinach (poi), spinach, chenopods, chekurmanis and indigenous vegetables of regional importance

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

**RESOURCES**

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

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

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

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

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

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

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

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

## VSC-531 PROTECTED CULTIVATION OF VEGETABLE CROPS (2+1)

**THEORY**

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

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

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

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

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

UNIT VI: *Solutions to problems*- Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for

seed production; Economics of greenhouse crop production

**PRACTICAL**

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

**RESOURCES**

Chadha, K.L. and Kalloo, G. (Eds.), 1993-94, Advances inhorticulture. 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, R. P., 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, H.M., 2012, Hydroponic food production. 7thEdn. CRC Press.

Singh, B., 2005, Protected cultivation of vegetable crops. Kalyani publishers, New Delhi Singh, D.K. and Peter, K.V., 2014, Protected cultivation of horticultural crops (1st Edition) New India publishing agency, New Delhi.

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

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

## VSC-532 ORGANIC VEGETABLE PRODUCTION (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, 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**

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

**RESOURCES**

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

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

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

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

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

## VSC-533 PROCESSING OF VEGETABLE CROPS (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

**RESOURCES**


Arthey, D. and Dennis, C., 1996, Vegetable processing. Blackie/Springer-Verlag. Chadha, D.S., 2006, *The* Prevention of food adulteration act. Confed. of Indian Industry. Desrosier, N.W., 1977, Elements and technology. AVI Publ. Co.

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, W.C. and Westhoff, D.C., 1995, Food microbiology. 4th Ed. Tata McGraw Hill. Giridharilal, G.S., Siddappa and Tandon, G.L., 1986, Preservation of fruits and vegetables. ICAR.

Gisela, J., 1985, Sensory evaluation of food- theory and practices. Ellis Horwood. Graham, H.D., 1980, Safety of foods. AVI Publ. Co.

Hildegrade, H. and Lawless, H.T., 1997, Sensory evaluation of food. CBS. Joslyn, M. and Heid, Food processing operations.AVI Publ. Co.

Mahindru, S.N., 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, R.P. and Kumar, S., 2003, Fruit and vegetable preservation: principles and practices. 3rd Ed. International Book Distri. Co.

Tressler and Joslyn, M.A., 1971, Fruit and vegetable juice processing technology. AVI Publ. Co. Verma, L.R. and Joshi, V.K., 2000, Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management. Indus Publ. Co.

## VSC-534 POSTHARVEST MANAGEMENT OF VEGETABLE CROPS (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: *Packinghouse operations*- Packing house operations; Commodity pretreatments chemicals, wax coating, precooling and irradiation; Packaging of vegetables, prevention from infestation, management of postharvest diseases and principles of transportation

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

**PRACTICAL**

a) Studies on stages and maturing indices
b) Ripening of commercially important vegetable crops
c) Studies of harvesting, pre-cooling, pre-treatments, physiological disorders- chilling injury
d) Improved packaging
e) Use of chemicals for ripening and enhancing shelf life of vegetables
f) Physiological loss in weight, estimation of transpiration, respiration rate and ethylene release
g) Storage of important vegetables
h) Cold chain management
i) Visit to commercial packinghouse, cold storage and control atmosphere storage

**RESOURCES**


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

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

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

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

Paliyath G., Murr D.P., Handa, A.K. and Lurie, S., 2008, Postharvest biology and technology of Fruits, vegetables and flowers. Wiley-Blackwell, ISBN: 9780813804088.

Ranganna, S., 1997, Handbook of analysis and quality control for fruit and vegetable Products. Tata McGraw-Hill.

Stawley, J. K., 1998, Postharvest physiology of perishable plant products. CBS publishers. Sudheer, K.P. and Indira, V., 2007, Postharvest technology of horticultural crops. New India Publ. Agency.

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

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

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

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

Wills, R.B.H. and Golding, J., 2017, Advances in postharvest fruit and vegetable technology, CRC Press, ISBN 978113889405.