

FACULTY OF AGRICULTURAL SCIENCES

Syllabus

M.Sc. Ag. Horticulture (Vegetable Science)
(2020-21)



**SHREE GURU GOBIND SINGH TRICENTENARY UNIVERSITY
GURUGRAM (DELHI-NCR)**

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1. Executive Summary

Agriculture is the primary source of livelihood for about 58% of India's population. Gross Value Added (GVA) by agriculture, forestry and fishing was estimated at Rs. 19.48 lakh crore (US\$ 276.37 billion) in FY20 (PE). Growth in GVA in agriculture and allied sectors stood at 4% in FY20. Horticulture plays a pivotal role in the food, nutrition and livelihood security of India. Though, horticultural crops occupy only 8.5% of arable land, they contribute 24.5% of the GDP in agriculture. Recently published special report of UN on the – 'Right to Food' estimated that nearly one billion people sleep without food across the world, and at every sixth second a child dies of malnutrition. Production of horticulture crops in India was estimated at a record 320.48 million metric tonnes (MMT) in FY20 as per second advance estimates. Plantation crops (tea, coffee and rubber) occupying 0.95% of cropped area have stake of 15.1% in the total export earnings. Horticulture and Plantation sector cover production, post-harvest management, marketing, processing and export of fruits, vegetables, flowers, medicinal and aromatic plants, plantation crops, spices, bamboo, mushroom, apiculture and sericulture. India is among the 15 leading exporters of agricultural products in the world. Agricultural export from India reached US\$ 38.54 billion in FY19 and US\$ 35.09 billion in FY20. The organic food segment including fruits and vegetables in India is expected to grow at a CAGR of 10% during 2015--25 and is estimated to reach Rs. 75,000 crore (US\$ 10.73 billion) by 2025 from Rs. 2,700 crore (US\$386.32 million) in 2015. India's performance on the fruit and vegetable production front is laudable but in value addition, processing and export segments the expected goals are not being realized. In spite of having a 10% share in global production of both fruits and vegetables, just 1.8% is processed and our export is a meagre 0.4%. The 11th Plan initiated a massive National Horticulture Mission with an outlay of Rs. 20,000 crores. The Private sector has come up with massive investments in corporate farming, processing and marketing.

The existing single M.Sc. Ag. Horticulture (Fruit Science) programme is quite inadequate to meet the present and future human-resource requirement. The programme needs to be expanded as done in the Syllabus of Horticulture for Agricultural Scientists Recruitment Board (ASRB) Examination. The proposed M.Sc. Ag. Horticulture programmes are:

- i). M. Sc. Ag. Horticulture (Fruit Science)
- ii). M. Sc. Ag. Horticulture (Vegetable Science)
- iii). M. Sc. Ag. Horticulture (Floriculture and Land Scape Architecture)
- iv). M. Sc. Ag. Horticulture (Plantation Crops, Spices, Medicinal and Aromatic Crops)

The syllabus in the existing single PG degree programme was expanded to meet the requirements of the four PG Programmes. The basic philosophy behind the revision was to:

- i). Increase the basic science content

- ii). Update the overall content in view of globalized economy
- iii). Imbibe technologies from developed countries
- iv). Comply with National and International Law in respect of food quality, standards and specifications
- v). Use ICT in Horticulture Education

Keeping pace with the educational reforms, The SGTU has planned to introduce the new programmes in a phased manner and **M.Sc.Ag.Horticulture (Vegetable Science)** is the second addition after already existing M. Sc. Ag. Horticulture (Fruit Science) programme under M.Sc. Ag. Horticulture.

The newly proposed **M.Sc. Ag. Horticulture (Vegetable Science)** programme will be on similar pattern as suggested by ICAR. Core and optional courses for vegetable crops have been included in the syllabus. Production technology, breeding and seed production of crops are covered under core courses. Introduction and history have been avoided from the syllabi as these are already covered at graduate level. Recent advances in biotechnology and protected cultivation, marker-assisted breeding, IPR issues, patenting, organic crop production and GAP are included in the syllabus. Production technology of underexploited crops and abiotic stress management has also been considered as relevant topics for PG curriculum. Reference section is enriched with the latest text books on the concerned subjects.

1.1. Organization of Course Contents & Credit Requirements

1.1.1. General Information about Course Code Numbers

- i). All courses for M.Sc. Ag. Horticulture (Vegetable Science) will be of 500-series.
- ii). Credit seminar has been designated by code no. 591, while code no. 599 pertains for Master's Research.

1.1.2. General Information about Course Contents

The contents of each course have been organized into:

- i). Objective (s) – to elucidate the basic purpose.
- ii). Theory units – to facilitate uniform coverage of syllabus for paper setting.
- iii). Suggested Readings – to recommend some standard books as reference material. This does not unequivocally exclude other such reference material that may be recommended according to the advancements and local requirements.
- iv). E-Resources - This may be useful as study material for research topics/ for quick update on specific topics/events pertaining to the subject.

1.1.3. Minimum Credit Requirement

Subject*	Master's Programme
Major	20
Minor	09
Supporting	05
Seminar	01
Research	20
Total Credit	55
Compulsory Non-Credit Courses	Section 5

*Major subject: The subject (department) in which the student takes admission

Minor subject: The subject closely related to student's major subject.

Supporting subject: The subject not related to the major subject. It could be any subject considered relevant for student's research work.

Compulsory Non-Credit Courses: Please see Section 5 for details. Six courses (PGS 501 to PGS 506) are of general nature and are compulsory for Master's programme.

2. Major Subject Courses

2.1. Courses' Structure at a Glance

Course Code (ICAR pattern)	Course Code (SGTU pattern)	Course Title	Credits
VSC 501*	11060202	PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS	3(2+1)
VSC 502*	11060304	PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS	3(2+1)
VSC 503*	11060212	BREEDING OF VEGETABLE CROPS	3(2+1)
VSC 504*	11060213	GROWTH AND DEVELOPMENT OF VEGETABLE CROPS	3(2+1)
VSC 505	11060401	SEED PRODUCTION TECHNOLOGY OF VEGETABLECROPS	3(2+1)
VSC 506	11060114	SYSTEMATICS OF VEGETABLE CROPS	2(1+1)
VSC 507	11060113	PRODUCTION TECHNOLOGY OF UNDER-EXPLOITED VEGETABLE CROPS	2(1+1)

VSC 508	11060310	ORGANIC VEGETABLE PRODUCTION TECHNOLOGY	2(1+1)
VSC 509	11060309	FUNDAMENTALS OF PROCESSING OF VEGETABLES	2(1+1)
VSC 591	11060405	MASTER'S SEMINAR	1(1+0)
VSC 599	11060406	MASTER'S RESEARCH	20

*** Compulsory Course**

2.2. Course Content

VSC 501/ 11060202: PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS 3(2+1)

Objective

To teach production technology of cool season vegetables.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production of:

UNIT I

Potato

UNIT II

Cole crops: cabbage, cauliflower, knol kohl, sprouting broccoli, Brusselssprout

UNIT III

Root crops: carrot, radish, turnip and beetroot

UNIT IV

Bulb crops: onion and garlic

UNIT V

Peas and broad bean, green leafy cool season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of winter vegetable crops and their economics; Experiments to demonstrate the role of mineral elements, plant growth substances and herbicides; study of physiological disorders; preparation of cropping scheme for commercial farms; visit to commercial green-house/ poly-house.

Suggested Readings:

- Bose TK & Som MG. (Eds.). 1986. Vegetable Crops in India. Naya Prokash.
- Bose TK, Som G & Kabir J. (Eds.). 2002. Vegetable Crops. Naya Prokash.
- Bose TK, Som MG & Kabir J. (Eds.). 1993. Vegetable Crops. Naya Prokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. Vegetable Crops. Vols. I-III. Naya Udyog.
- Chadha KL & 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 & Sons.
- Decoteau DR. 2000. Vegetable Crops. Prentice Hall.
- Edmond JB, Musser AM & Andrews FS. 1951. Fundamentals of Horticulture. Blakiston Co.
- Fageria MS, Choudhary BR & Dhaka RS. 2000. Vegetable Crops: Production Technology. Vol. II. Kalyani.
- Gopalakrishnan TR. 2007. Vegetable Crops. New India Publ. Agency.
- Hazra P & Som MG. (Eds.). 1999. Technology for Vegetable Production and Improvement. Naya Prokash.
- Rana MK. 2008. Olericulture in India. Kalyani Publ.
- Rana MK. 2008. Scientific Cultivation of Vegetables. Kalyani Publ.
- Rubatzky VE & Yamaguchi M. (Eds.). 1997. World Vegetables: Principles, Production and Nutritive Values. Chapman & Hall.
- Saini GS. 2001. A Text Book of Olericulture and Floriculture. Aman Publ. House.
- Salunkhe DK & Kadam SS. (Eds.). 1998. Hand Book of Vegetable Science and Technology: Production, Composition, Storage and Processing. Marcel Dekker.
- Shanmugavelu KG. 1989. Production Technology of Vegetable Crops. Oxford & IBH.
- Singh DK. 2007. Modern Vegetable Varieties and Production Technology. International Book Distributing Co.
- Singh SP. (Ed.). 1989. Production Technology of Vegetable Crops. Agril. Comm. Res. Centre.
- Thamburaj S & Singh N. (Eds.). 2004. Vegetables, Tuber Crops and Spices. ICAR.
- Thompson HC & Kelly WC. (Eds.). 1978. Vegetable Crops. Tata McGrawHill.

VSC 502/ 11060304: PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS 3(2+1)

Objective

To teach production technology of warm season vegetables.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures, economics of crop production and seed production of:

UNIT I

Tomato, eggplant, hot and sweet peppers

UNIT II

Okra, beans, cowpea and cluster-bean

UNIT III

Cucurbitaceous crops

UNIT IV

Tapioca and sweet potato

UNIT V

Green leafy warm season vegetables

Practical

Cultural operations (fertilizer application, sowing, mulching, irrigation, weed control) of summer vegetable crops and their economics; study of physiological disorders and deficiency of mineral elements, preparation of cropping schemes for commercial farms; experiments to demonstrate the role of mineral elements, physiological disorders; plant growth substances and herbicides; seed extraction techniques; identification of important pests and diseases and their control; maturity standards; economics of warm season vegetable crops.

Suggested Readings

- Bose TK & Som MG. (Eds.). 1986. Vegetable Crops in India. Naya Prokash.
- Bose TK, Kabir J, Maity TK, Parthasarathy VA & Som MG. 2003. Vegetable Crops. Vols. I-III. Naya Udyog.
- Bose TK, Som MG & Kabir J. (Eds.). 2002. Vegetable Crops. Naya Prokash. Brown HD & Hutchison CS. Vegetable Science. JB Lippincott Co.
- Chadha KL & 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 & Sons.
- Decoteau DR. 2000. Vegetable Crops. Prentice Hall.
- Edmond JB, Musser AM & Andrews FS. 1964. Fundamentals of Horticulture. Blakiston Co
- Fageria MS, Choudhary BR & Dhaka RS. 2000. Vegetable Crops: Production Technology. Vol. II. Kalyani.

- Gopalakrishanan TR. 2007. Vegetable Crops. New India Publ. Agency.
- Hazra P & Som MG. (Eds.). 1999. Technology for Vegetable Production and Improvement. Naya Prokash.
- Kalloo G & Singh K (Ed.). 2000. Emerging Scenario in Vegetable Research and Development. Research Periodicals & Book Publ. House.
- Nayer NM & More TA 1998. Cucurbits. Oxford & IBH Publ.
- Palaniswamy & Peter KV. 2007. Tuber Crops. New India Publ. Agency.
- Pandey AK & Mudranalay V. (Eds.). Vegetable Production in India: Important Varieties and Development Techniques.
- Rana MK. 2008. Olericulture in India. Kalyani.
- Rana MK. 2008. Scientific Cultivation of Vegetables. Kalyani.
- Rubatzky VE & Yamaguchi M. (Eds.). 1997. World Vegetables: Principles, Production and Nutritive Values. Chapman & Hall.
- Saini GS. 2001. A Text Book of Olericulture and Floriculture. Aman Publ. House.
- Salunkhe DK & 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 & IBH.

VSC503/11060212: BREEDING OF VEGETABLE CROPS3(2+1)

Objective

To educate students regarding principles and practices adopted for breeding of vegetable crops.

Theory

Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, molecular marker, genomics, marker assisted breeding and QTLs, biotechnology and their use in breeding in vegetable crops-Issue of patenting, PPVFR act.

UNIT I

Potato and tomato

UNIT II

Eggplant, hot pepper, sweet pepper and okra

UNIT III

Peas and beans, amaranth, chenopods and lettuce

UNIT IV

Gourds, melons, pumpkins and squashes

UNIT V

Cabbage, cauliflower, carrot, beetroot, radish, sweet potato and tapioca

Practical

Selection of desirable plants from breeding population observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations; induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops; hybrid seed production of vegetable crops in bulk. screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops, demonstration of sib-mating and mixed population; molecular- marker techniques to identify useful traits in the vegetable crops and special breeding techniques. Visit to breeding blocks.

Suggested Readings:

- Allard RW. 1999. Principles of Plant Breeding. John Wiley & Sons.
- Basset MJ. (Ed.). 1986. Breeding Vegetable Crops. AVI Publ.
- Dhillon BS, Tyagi RK, Saxena S. & Randhawa GJ. 2005. Plant Genetic Resources: Horticultural Crops. Narosa Publ. House.
- Fageria MS, Arya PS & Choudhary AK. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani.
- Gardner EJ. 1975. Principles of Genetics. John Wiley & Sons.
- Hayes HK, Immer FR & Smith DC. 1955. Methods of Plant Breeding. McGraw-Hill.
- Hayward MD, Bosemark NO & Romagosa I. (Eds.). 1993. Plant Breeding Principles and Prospects. Chapman & Hall.
- Kalloo G. 1988. Vegetable Breeding. Vols. I-III. CRC Press.
- Kalloo G. 1998. Vegetable Breeding. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
- Kumar JC & Dhaliwal MS. 1990. Techniques of Developing Hybrids in Vegetable Crops. Agro Botanical Publ.
- Paroda RS & Kalloo G. (Eds.). 1995. Vegetable Research with Special Reference to Hybrid Technology in Asia-Pacific Region. FAO.
- Peter KV & Pradeep Kumar T. 2008. Genetics and Breeding of Vegetables. Revised, ICAR.
- Rai N & Rai M. 2006. Heterosis Breeding in Vegetable Crops. New India Publ. Agency.
- Ram HH. 1998. Vegetable Breeding: Principles and Practices. Kalyani. Simmonds NW. 1978. Principles of Crop Improvement. Longman.
- Singh BD. 1983. Plant Breeding. Kalyani.
- Singh PK, Dasgupta SK & Tripathi SK. 2004. Hybrid Vegetable Development. International Book Distributing Co.
- Swarup V. 1976. Breeding Procedure for Cross-pollinated Vegetable Crops. ICAR.

VSC504/110602013: GROWTH AND DEVELOPMENT OF VEGETABLE CROPS 3 (2+1)

Objective

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

Theory

UNIT I

Cellular structures and their functions; definition of growth and development, growth analysis and its importance in vegetable production.

UNIT II

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

UNIT III

Role of light, temperature and photoperiod on growth, development of underground parts, flowering and sex expression in vegetable crops; apical dominance.

UNIT IV

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

Plant growth regulators in relation to vegetable production; morphogenesis and tissue culture techniques in vegetable crops.

Practical

Preparation of solutions of plant growth substances 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.

Suggested Readings

- Bleasdale JKA. 1984. Plant Physiology in Relation to Horticulture. 2nd Ed. MacMillan.
- Gupta US. (Ed.). 1978. Crop Physiology. Oxford & IBH.
- Krishnamoorti HN. 1981. Application Plant Growth Substances and Their Uses in Agriculture. Tata-McGraw Hill.
- Peter KV. (Ed.). 2008. Basics of Horticulture. New India Publ. Agency.
- Saini RS, Sharma KD, Dhankhar OP & Kaushik RA. (Eds.). 2001. Laboratory Manual of Analytical Techniques in Horticulture. Agrobios.
- Wien HC. (Ed.). 1997. The Physiology of Vegetable Crops. CABI.

VSC505/ 11060401: SEED PRODUCTION TECHNOLOGY OF VEGETABLE CROPS3(2+1)

Objective

To educate students regarding principles and methods of quality seed and planting material production in vegetable crops.

Theory

UNIT I

Definition of seed and its quality, new seed policies; DUS test, scope of vegetable seed industry in India.

UNIT II

Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behaviour, seed development and maturation; methods of hybrid seed production.

UNIT III

Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control.

UNIT IV

Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/packets), storage and cryopreservation of seeds, synthetic seed technology.

UNIT V

Agro-techniques for seed production in solanaceous vegetables, cucurbits, leguminous vegetables, cole crops, bulb crops, leafy vegetables, okra, vegetatively propagated vegetables.

Practical

Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, physical purity) and seed health testing; testing, releasing and notification procedures of varieties; floral biology; rouging of off-types; methods of hybrid seed production in important vegetable and spice crops; seed extraction techniques; handling of seed processing and seed testing equipment; seed sampling; testing of vegetable seeds for seed purity, germination, vigour and health; visit to seed processing units, seed testing laboratory and seed production farms.

Suggested Readings:

- Agrawal PK & Dadlani M. (Eds.). 1992. Techniques in Seed Science and Technology. South Asian Publ.
- Agrawal RL. (Ed.). 1997. Seed Technology. Oxford & IBH.
- Bendell PE. (Ed.). 1998. Seed Science and Technology: Indian Forestry Species. Allied Publ.
- Fageria MS, Arya PS & Choudhary AK. 2000. Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani.

- George RAT. 1999. Vegetable Seed Production. 2nd Ed. CABI.
- Kumar JC & Dhaliwal MS. 1990. Techniques of Developing Hybrids in Vegetable Crops. Agro Botanical Publ.
- More TA, Kale PB & Khule BW. 1996. Vegetable Seed Production Technology. Maharashtra State Seed Corp.
- Rajan S & Baby L Markose. 2007. Propagation of Horticultural Crops. New India Publ. Agency.
- Singh NP, Singh DK, Singh YK & Kumar V. 2006. Vegetable Seed Production Technology. International Book Distributing Co.
- Singh SP. 2001. Seed Production of Commercial Vegetables. Agrotech Publ. Academy.

VSC 506/11060114: SYSTEMATICS OF VEGETABLE CROPS 2(1+1)

Objective

To teach morphological, cytological and molecular taxonomy of vegetable crops.

Theory

UNIT I

Principles of classification; different methods of classification; salient features of international code of nomenclature of vegetable crops.

UNIT II

Origin, history, evolution and distribution of vegetable crops, botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables.

UNIT III

Cytological level of various vegetable crops; descriptive keys for important vegetables.

UNIT IV

Importance of molecular markers in evolution of vegetable crops; molecular-markers as an aid in characterization and taxonomy of vegetable crops.

Practical

Identification, description, classification and maintenance of vegetable species and varieties; survey, collection of allied species and genera locally available; preparation of keys to the species and varieties; methods of preparation of herbarium and specimens.

Suggested Readings

- Dutta AC. 1986. A Class Book of Botany. Oxford Univ. Press.
- Pandey BP. 1999. Taxonomy of Angiosperm. S. Chand & Co.
- Peter KV & Pradeep Kumar T. 2008. Genetics and Breeding of Vegetables (Revised), ICAR.
- Soule J. 1985. Glossary for Horticultural Crops. John Wiley & Sons.
- Srivastava U, Mahajan RK, Gangopadhyay KK, Singh M & Dhillon BS. 2001. Minimal Descriptors of Agri-Horticultural Crops. Part-II: Vegetable Crops. NBPGR, New Delhi.

- Vasistha. 1998. Taxonomy of Angiosperm. Kalyani.
- Vincent ER & Yamaguchi M. 1997. World Vegetables. 2nd Ed. Chapman &Hall.

VSC507/11060113: PRODUCTION TECHNOLOGY OF UNDER-EXPLOITED VEGETABLE CROPS 2(1+1)

Objective

To educate students regarding production technology of under-utilized vegetable crops.

Theory

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production of:

UNIT I

Asparagus, artichoke and leek

UNIT II

Brussels's sprout, Chinese cabbage, broccoli, kale and artichoke.

UNIT III

Amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathu(chenopods) and chekurmanis.

UNIT IV

Elephant foot yam, lima bean, winged bean, vegetable pigeon pea, jackbean and sword bean.

UNIT V

Sweet gourd, spine gourd, pointed gourd, Oriental pickling melon and littlegourd (kundru).

Practical

Identification of seeds; botanical description of plants; layout and planting;cultural practices; short-term experiments of under-exploited vegetables.

Suggested Readings:

- Bhat KL. 2001. Minor Vegetables - Untapped Potential. Kalyani.
- Indira P & Peter KV. 1984. Unexploited Tropical Vegetables. Kerala Agricultural University, Kerala.
- Peter KV. (Ed.). 2007-08. Underutilized and Underexploited Horticultural Crops. Vols. I-IV. New India Publ. Agency.
- Rubatzky VE & Yamaguchi M. (Eds.). 1997. World Vegetables: Principles, Production and Nutritive Values. Chapman & Hall

- Srivastava U, Mahajan RK, Gangopadyay KK, Singh M & Dhillon BS.2001. Minimal Descriptors of Agri-Horticultural Crops. Part-II:Vegetable Crops. NBPGR, New Delhi.

VSC 508/11060310: ORGANIC VEGETABLE PRODUCTIONTECHNOLOGY 2(1+1)

Objective:

To teach principles, concepts and production of organic farming in vegetable crop

Theory

UNIT I

Importance, principles, perspective, concept and component of organic production of vegetable crops.

UNIT II

Organic production of vegetables crops, viz., solanaceous crops, cucurbits, cole crops, root and tuber crops.

UNIT III

Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture; processing and quality control for organic foods.

UNIT IV

Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, Panchagavya, Biodynamics, preparation etc. Pest and disease management in organic farming; ITK's in organic farming. Role of botanicals and bio-control agents.

UNIT V

GAP and GMP- Certification of organic products; organic production and export - opportunity and challenges.

Practical

Method of preparation of compost, vermicompost, biofertilizers; soil solarization, bio pesticides in horticulture, green manuring, mycorrhizae and organic crop production, waste management, organic soil amendment for root disease, weed management in organic horticulture. Visit to organic fields and marketing centers.

Suggested Readings

- Dahama AK. 2005. Organic Farming for Sustainable Agriculture. 2nd Ed. Agrobios.
- Gehlot G. 2005. Organic Farming; Standards, Accreditation Certification and Inspection. Agrobios.

- Palaniappan SP & Annadorai K. 2003. Organic Farming, Theory and Practice. Scientific Publ.
- Pradeep Kumar T, Suma B, Jyothibhaskar & 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, 1997, UAS, Bangalore.

VSC 509/11060309: FUNDAMENTALS OF PROCESSING OF VEGETABLES2(1+1)

Objective

To educate students regarding principles and practices of processing of vegetable crops.

Theory

UNIT I

History of food preservation. Present status and future prospects of vegetable preservation industry in India.

UNIT II

Spoilage of fresh and processed horticultural produce; biochemical changes and enzymes associated with spoilage of horticultural produce; principal spoilage organisms, food poisoning and their control measures. Role of microorganisms in food preservation.

UNIT III

Raw materials for processing. Primary and minimal processing; processing equipment; Layout and establishment of processing industry, FPO license. Importance of hygiene; Plant sanitation.

UNIT IV

Quality assurance and quality control, TQM, GMP. Food standards – FPO, PFA, etc. Food laws and regulations.

UNIT V

Food safety – Hazard analysis and critical control points (HACCP). Labeling and labeling act, nutrition labeling.

UNIT VI

Major value-added products from vegetables. Utilization of byproducts of vegetable processing industry; Management of waste from processing factory.

UNIT VII

Investment analysis. Principles and methods of sensory evaluation of fresh and processed vegetables.

Practical

Study of machinery and equipment used in processing of horticultural produce; Chemical analysis for nutritive value of fresh and processed vegetables; Study of different types of spoilages in fresh as well as processed horticultural 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, equipment, hygiene, sanitation and residual / waste management.

Suggested Readings:

- Arthey D & Dennis C. 1996. Vegetable Processing. Blackie/Springer Verlag.
- Chadha DS. 2006. The Prevention of Food Adulteration Act. Confed. of Indian Industry.
- Desrosier NW. 1977. Elements and Technology. AVI Publ. Co. FAO. 1997. Fruit and Vegetable Processing. FAO.
- FAO. CODEX Alimentarius: Joint FAO/WHO Food Standards Programme. 2nd Ed. Vol. VB. Tropical Fresh Fruits and Vegetables. FAO.
- FAO. Food Quality and Safety Systems – Training Manual on Food Hygiene and HACCP.
- FAO. Fellow's P. 1988. Food Processing Technology. Ellis Horwood International.
- Frazier WC & Westhoff DC. 1995. Food Microbiology. 4th Ed. Tata McGraw Hill.
- Giridharilal GS, Siddappa & Tandon GL. 1986. Preservation of Fruits and Vegetables. ICAR.
- Gisela J. 1985. Sensory Evaluation of Food – Theory and Practices. Ellis Horwood.
- Graham HD. 1980. Safety of Foods. AVI Publ. Co.
- Hildegrade H & Lawless HT. 1997. Sensory Evaluation of Food. CBS. Joslyn M & Heid. Food Processing Operations. AVI Publ. Co.
- Mahindru SN. 2004. Food Safety: Concepts and Reality. APH Publ. Corp.
- Ranganna S. 1986. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Ed. Tata-McGraw Hill.
- Shapiro R. 1995. Nutrition Labeling Handbook. Marcel Dekker.
- Srivastava RP & Kumar S. 2003. Fruit and Vegetable Preservation: Principles and Practices. 3rd Ed. International Book Distrib. Co.
- Tressler & Joslyn MA. 1971. Fruit and Vegetable Juice Processing Technology. AVI Publ. Co.
- Verma LR & Joshi VK. 2000. Post-harvest Technology of Fruits and Vegetables: Handling, Processing, Fermentation and Waste Management. Indus Publ. Co.

3. Minor Subject

The student admitted for M.Sc. Ag. Horticulture (Vegetable Science) will study Fruit Science as the minor subject.

3.1. Courses' Structure at a Glance

Course Code (ICAR)	Course Code (SGTU)	Course Title	Credits

pattern)	pattern)		
FSC 501	11060101	TROPICAL AND DRY LAND FRUIT PRODUCTION	3(2+1)
FSC 502	11060102	SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION	3(2+1)
FSC 503	11060201	BIODIVERSITY AND CONSERVATION OF FRUIT CROPS	3(2+1)
FSC 505	11060302	PROPAGATION AND NURSERY MANAGEMENT FOR FRUIT CROPS	3(2+1)
FSC 506	11060301	BREEDING OF FRUIT CROPS	3(2+1)
FSC 507	11060103	POST HARVEST TECHNOLOGY FOR FRUIT CROPS	3(2+1)
FSC 512	11060303	GAP FOR HORTICULTURAL CROPS	1(1+0)
FSC 513	11060104	CLIMATE MANAGEMENT IN HORTICULTURAL PRODUCTION	1(1+0)

3.1.1.Course Contents

FSC 501/11060101: TROPICAL AND DRY LAND FRUIT PRODUCTION 3(2+1)

Objective

To impart basic knowledge about the importance and management of tropical and dry land fruits grown in India.

Theory

Commercial varieties of regional, national and international importance, eco-physiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bio-regulators, abiotic factors limiting fruit production, physiology of flowering, pollination fruit set and development, honeybees in cross pollination, physiological disorders- causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones (AEZ) and industrial supports.

Crops

UNIT-I

Mango and Banana

UNIT-II

Citrus and Papaya

UNIT-III

Guava, Sapota and Jackfruit

UNIT-IV

Pineapple, Annonas and Avocado

UNIT-V

Ber, Aonla, Bael, Pomegranate, Phalsa, Karonda, Mulberry, Ker, Salvadora, Lasoda and, minor fruits of tropics

Practical

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to tropical and arid zone orchards, project preparation for establishing commercial orchards.

Suggested Readings

- Bose TK, Mitra SK & Rathore DS. (Eds.). 1988. Temperate Fruits -Horticulture. Allied Publ.
- Bose TK, Mitra SK & Sanyal D. 2001. (Eds.). Fruits -Tropical and Subtropical. Naya Udyog.
- Chadha KL & Pareek OP. 1996. (Eds.). Advances in Horticulture. Vols. II–IV, Malhotra Publ. House.
- Nakasone HY & Paul RE. 1998. Tropical Fruits. CABI.
- Peter KV. 2008. (Ed.). Basics of Horticulture. New India Publ. Agency.
- Pradeepkumar T, Suma B, Jyothibhaskar&Satheesan KN. 2008. Management of Horticultural Crops. Parts I, II. New India Publ. Agency.
- Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency.
- Singh HP, Negi JP & Samuel JC. (Eds.). 2002. Approaches for Sustainable Development of Horticulture. National Horticultural Board.
- Singh HP, Singh G, Samuel JC & Pathak RK. (Eds.). 2003. Precision Farming in Horticulture. NCPAH, DAC/PFDC, CISH, Lucknow.

FSC 502/11060102: SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION 3(2+1)

Objective

To impart basic knowledge about the importance and management of subtropical and temperate fruits grown in India.

Theory

Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, bioregulation, biotic factors limiting fruit production, physiology of flowering, fruit

set and development, abiotic factors limiting production, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, precooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones (AEZ) and industrial support.

Crops

UNIT-I

Apple, pear, quince, grapes

UNIT-II

Plums, peach, apricot, cherries, hazelnut

UNIT-III

Litchi, loquat, persimmon, kiwifruit, strawberry

UNIT-IV

Nuts- walnut, almond, pistachio, pecan

UNIT-V

Minor fruits- mangosteen, carambola, bael, wood apple, fig, jamun, rambutan, pomegranate

Practical

Identification of important cultivars, observations on growth and development, practices in growth regulation, malady diagnosis, analyses of quality attributes, visit to subtropical and temperate orchards, Project preparation for establishing commercial orchards.

Suggested Readings

- Bose TK, Mitra SK & Sanyal D. (Ed.). 2002. Fruits of India – Tropical and Sub-tropical. 3rd Ed. Vols. I, II. Naya Udyog.
- Chadha KL & Pareek OP. 1996. (Eds.). Advances in Horticulture. Vol. I. Malhotra Publ. House.
- Chadha KL & Shikhamany SD. 1999. The Grape: Improvement, Production and Post-Harvest Management. Malhotra Publ. House.
- Janick J & Moore JN. 1996. Fruit Breeding. Vols. I-III. John Wiley & Sons. Nijjar GS. 1977. (Eds.). Fruit Breeding in India. Oxford & IBH.
- Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency.
- Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. Advances in Citriculture. Jagmander Book Agency.

FSC 503/11060201: BIODIVERSITY AND CONSERVATION OF FRUIT CROPS 3(2+1)

Objective

Understanding the principles of biodiversity and strategies in germplasm conservation of fruit crops.

Theory

UNIT-I

Biodiversity and conservation; issues and goals, centers of origin of cultivated fruits; primary and secondary centers of genetic diversity.

UNIT-II

Present status of gene centers; exploration and collection of germplasm; conservation of genetic resources – conservation *in situ* and *ex situ*.

UNIT-III

Germplasm conservation- problem of recalcitrancy - cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine.

UNIT-IV

Intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group.

UNIT-V

GIS and documentation of local biodiversity, Geographical indication.

Crops

Mango, sapota, citrus, guava, banana, papaya, grapes, jackfruit, custard apple, ber, aonla, *Malus* spp., *Prunus* spp., litchi, nuts, coffee, tea, rubber, cashew, coconut, cocoa, palmyrah, arecanut, oil palm and betelvine.

Practical

Documentation of germplasm – maintenance of passport data and other records of accessions; field exploration trips, 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, core sampling, germplasm characterization using molecular techniques.

Suggested Readings

- Frankel OH & Hawkes JG. 1975. Crop Genetic Resources for Today and Tomorrow. Cambridge University Press.
- Peter KV & Abraham Z. 2007. Biodiversity in Horticultural Crops. Vol.I. Daya Publ. House.
- Peter KV. 2008. Biodiversity of Horticultural Crops. Vol. II. Daya Publ. House.

FSC 505/11060302: PROPAGATION AND NURSERY MANAGEMENT FOR FRUIT CROPS 3(2+1)

Objective

Familiarization with principles and practices of propagation and nursery management for fruit crops.

Theory

UNIT-I

Introduction, life cycles in plants, cellular basis for propagation, sexual propagation, apomixis, polyembryony, chimeras. Principles factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth.

UNIT-II

Seed quality, treatment, packing, storage, certification, testing. Asexual propagation – rooting of soft and hard wood cutting under mist by growth regulators. Rooting of cuttings in hotbeds. Physiological, anatomical and biochemical aspects of root induction in cuttings. Layering – principle and methods.

UNIT-III

Budding and grafting – selection of elite mother plants, methods. Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility. Rejuvenation through top working – Progeny orchard and scion bank.

UNIT-IV

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

UNIT-V

Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production.

Practical

Anatomical studies in rooting of cutting and graft union, construction of propagation structures, study of media and PGR. Hardening – case studies, micropropagation, explant preparation, media preparation, culturing – *in vitro* clonal propagation, meristem culture, shoot tip culture, axillary bud culture, direct organogenesis, direct and indirect embryogenesis, micro grafting, hardening. Visit to TC labs and nurseries.

Suggested Readings

- Hartmann HT & Kester DE. 1989. Plant Propagation – Principles and Practices. Prentice Hall of India.
- Bose TK, Mitra SK & Sadhu MK. 1991. Propagation of Tropical and Subtropical Horticultural Crops. Naya Prokash.
- Peter KV. (Ed.). 2008. Basics of Horticulture. New India Publ. Agency. Singh SP. 1989 Mist Propagation. Metropolitan Book Co.
- Rajan S & Baby LM. 2007. Propagation of Horticultural Crops. New India Publ. Agency.
- Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency.

FSC 506/11060301: BREEDING OF FRUIT CROPS 3(2+1)

Objective

To impart comprehensive knowledge about the principles and practices of breeding of fruit crops.

Theory

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, ideotypes, approaches for crop improvement - introduction, selection, hybridization, mutation breeding, polyploidy breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops.

Crops

UNIT-I

Mango, banana and pineapple

UNIT-II

Citrus, grapes, guava and sapota

UNIT-III

Jackfruit, papaya, custard apple, aonla, avocado and ber

UNIT-IV

Mangosteen, litchi, jamun, phalsa, mulberry, raspberry, kokam and nuts

UNIT-V

Apple, pear, plums, peach, apricot, cherries and strawberry

Practical

Characterization of germplasm, blossom biology, study of anthesis, estimating fertility status, practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for resistance, developing breeding programme for specific traits, visit to research stations working on tropical, subtropical and temperate fruit improvement.

Suggested Readings

- Bose TK, Mitra SK & Sanyal D. (Eds.). 2002. Fruits of India – Tropical and Sub-tropical. 3rd Ed. Vols. I, II. Naya Udyog.
- Chadha KL & Pareek OP. 1996. (Eds.). Advances in Horticulture. Vol. I. Malhotra Publ. House.
- Chadha KL & Shikhamany SD. 1999. The Grape: Improvement, Production and Post-Harvest Management. Malhotra Publ. House.
- Janick J & Moore JN. 1996. Fruit Breeding. Vols. I-III. John Wiley & Sons. Nijjar GS. 1977. (Eds.). Fruit Breeding in India. Oxford & IBH.
- Radha T & Mathew L. 2007. Fruit Crops. New India Publ. Agency.
- Singh S, Shivankar VJ, Srivastava AK & Singh IP. (Eds.). 2004. Advances in Citriculture. Jagmander Book Agency.

FSC 507/11060103: POST HARVEST TECHNOLOGY FOR FRUIT CROPS 3(2+1)

Objective

To facilitate deeper understanding on principles and practices of postharvest management of fruit crops.

Theory

UNIT-I

Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration.

UNIT-II

Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling.

UNIT-III

Treatments prior to shipment, *viz.*, chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage ventilation, refrigeration, modified atmospheric storage, controlled atmospheric storage, physical injuries and disorders.

UNIT-IV

Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies.

UNIT-V

Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

Practical

Analyzing maturity stages of commercially important fruit crops, improved packing and storage of important fruit crops, physiological loss in weight of fruits, estimation of transpiration, respiration rate, estimation of quality characteristics in stored fruits, cold chain management visit to cold storage and CA storage units, visit to fruit processing units, project preparation, evaluation of processed fruit products.

Suggested Readings

- Bhutani RC. 2003. Fruit and Vegetable Preservation. Biotech Books.
- Chadha KL & Pareek OP. (Eds.). 1996 Advances in Horticulture. Vol. IV. Malhotra Publ. House.
- Haid NF & Salunkhe SK. 1997. Post Harvest Physiology and Handling of Fruits and Vegetables. Grenada Publ.
- Mitra SK. 1997. Post Harvest Physiology and Storage of Tropical and Sub-tropical Fruits. CABI.
- Ranganna S. 1997. Hand Book of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill.
- Sudheer KP & Indira V. 2007. Post Harvest Technology of Horticultural Crops. New India Publ. Agency.
- Willis R, Mc Glassen WB, Graham D & Joyce D. 1998. Post Harvest. An Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals. CABI.

FSC 512/11060303: GAP FOR HORTICULTURAL CROPS 1(1+0)

Objective

To impart comprehensive knowledge about the principles and practices of Good Agricultural Practises (GAP) for horticultural crops.

Theory

UNIT-I

Genesis of GAP – definition/description, components listed by FAO, frame work.

UNIT-II

Management of site history and soil, crop and fodder production, IPM, INM, IWM, irrigation water, crop production and protection. Identification of ways of improving the productivity profitability, and resource efficiency. harvest and post-harvest handling.

UNIT-III

Animal production, product certification, animal waste management, animal health and welfare, harvest.

UNIT-IV

On farm processing, storage, energy and waste management, human health, welfare, safety, wild life benefits.

UNIT-V

Institutions involved in GAP certification. Indian agencies, EUREPGAP (European Retail Producers Group- Good Agricultural Practices), EUREP etc.

Suggested Readings

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

FSC 513/11060104: CLIMATE MANAGEMENT IN HORTICULTURAL PRODUCTION 1(1+0)

Objective

To develop understanding about the impact and management of climate in horticultural production.

Theory

UNIT-I

Introduction to climate change. Factors directly connected to climate change, average temperature, change in rainfall amount and patterns, rising atmospheric concentrations of CO₂, pollution levels such as tropospheric ozone, change in climatic variability and extreme events like receding of glaciers in Himalayas.

UNIT-II

Sensors for climate registration and crop monitoring, phytomonitoring and biosensors, plants response to the climate changes, premature bloom, marginally overwintering or inadequate winter chilling hours, insect pests, longer growing seasons and shifts in plant hardiness for perennial fruit crops, flowering plants and other plant species.

UNIT-III

Impact of climate changes on invasive insect, disease, weed, pests, horticulture yield, quality and sustainability, climate management in field production – mulching - use of plastic- windbreak- spectral changes- frost protection. Climate management in greenhouse- heating - vents - CO2 injection - screens - artificial light.

UNIT-IV

Climate management for control of pests, diseases, quality, elongation of growth and other plant processes- closed production systems around the world. Special protected cultivation now and in the future, growth chambers, production in space, biosphere, future aspects of close production, future greenhouse, use of LED as artificial light, future sensor types etc. clean development mechanism, role of tropical trees.

Suggested Readings

- Peter KV. 2008. (Ed.). Basics of Horticulture. New India Publ. Agency.
- Rao GSLHV, Rao GGSN, Rao VUM & Ramakrishnan YS. 2008. Climate Change and Agriculture over India. ICAR.
- Rao GSLHV. 2008. Agricultural Meteorology. Prentice Hall.

4. Basic Supporting Courses

4.1. Courses' Structure at a Glance

Course Code (ICAR pattern)	Course Code (SGTU pattern)	Course Title	Credits
FST 455	11060203	EXPERIMENTAL DESIGNS	3(2+1)
PP 501	11060107	PRINCIPLES OF PLANT PHYSIOLOGY	4(3+1)
*SOILS 511	11060105	ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS	2(0+2)

* Compulsory for students taking research problem related to nutrition requirement of vegetable crops

4.1.1. Course Content

FST 455/ 11060203: EXPERIMENTAL DESIGNS 3(2+1)

Objective

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

Theory

UNIT I

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

UNIT II

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

UNIT III

Factorial experiments, (symmetrical as well as asymmetrical). orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV

Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, Lattice design, Response surfaces.

UNIT V

Bioassays- direct and indirect, potency estimation.

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data; Fitting of response surfaces and Bioassays.

Suggested Readings

- Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
- Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer.
- Federer WT. 1985. Experimental Designs. MacMillan.
- Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
- Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publication
- Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley.
- Design Resources Server: [www.iasri.res.in /design](http://www.iasri.res.in/design).

PP 501/11060107: PRINCIPLES OF PLANT PHYSIOLOGY 4(3+1)

Theory

UNIT I

Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells. Mechanism of water uptake by roots-transport in roots, aquaporins, movement of water in plants – Mycorrhizal association on water uptake.

UNIT II

Water loss from plants-Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration transpiration –Driving force for transpiration, plant factors influencing transpiration rate. Stomata structure and function – mechanism of stomatal movement, anti-transpirants. Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

UNIT III

The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants. Uptake of mineral elements in plants –Mechanisms of uptake-translocation of minerals in plants. Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition.

UNIT IV

Photosynthesis and its importance in bio productivity. Photochemical process, photochemical reactions, CO₂ reduction in Calvin cycle, supplementary pathway of C fixation in C₄ and CAM plants and its significance. Photorespiration and its relevance. Photosynthesis as a diffusive process effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall). Translocation of photosynthates and its importance in sink growth. Secondary metabolites and their significance in plant defense mechanism.

UNIT V

Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones and their physiological role synthetic growth regulators, growth retardants., Apical dominance, senescence, fruit growth, abscission. Photo morphogenesis: Photo receptors, phytochrome, cryptochrome, physiology of flowering- Photoperiodism and Vernalization. Practical Measurement of soil water status: Theory and principle of pressure plate apparatus, neutron probe,

Practical

Measurement of plant water status: Relative water content, water saturation deficits Chardakov's test. Theory and principle of pressure bomb, psychrometer and osmometer, Measurement of transpiration rate. Measurement of vapour pressure deficits, theory and principle of porometry, diffusion porometer and Steady state porometer, Stomatal physiology, influence of ABA on stomatal closing. Mineral nutrients: Demonstration of energy requirement for ion uptake. Deficiency symptoms of nutrients, Radiant energy measurements, separation and quantification of chlorophylls, O₂ evolution during photosynthesis, Measurement of gas exchange parameters, conductance, photosynthetic rate, photorespiration, Respiration rates, Estimation of reducing sugars, starch. Estimation of NO₃, free aminoacids in the xylem exudates, quantification of soluble proteins. Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene. Demonstration of photoperiodic response of plants in terms of flowering.

Suggested Readings

- Hopkins WG &Huner NPA. 2004. Introduction to Plant Physiology.
- John Wiley & Sons. Salisbury FB & Ross C. 1992. Plant Physiology. 4th Ed. Wadsworth Publ.
- Taiz L & Zeiger E. 2006. Plant Physiology. 4th Ed. Sinauer Associates.

SOILS 511/ 11060105: ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS 2(0+2)

Objective

To familiarize the students with commonly used instruments – their working, preparations of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Practical

UNIT I

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

UNIT II

Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

UNIT III

Principles of visible, ultraviolet and infrared spectro-photometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray refractrometry; identification of minerals by X-ray by different methods.

UNIT IV

Electrochemical titration of clays; determination of cation and anion exchange capacities of soils; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

UNIT V

Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; analysis of plant materials by digesting plant materials by wet and dry ashing and soil by wet digestion methods.

UNIT VI

Determination of lime and gypsum requirement of soil; drawing normalized exchange isotherms; measurement of redox potential.

UNIT VII

Analysis of soil extracts and irrigation waters for their soluble cations and anions and interpretation of results.

Suggested Readings

- Hesse P. 971. Textbook of Soil Chemical Analysis. William Clowes & Sons.
- Jackson ML. 1967. Soil Chemical Analysis. Prentice Hall of India.
- Keith A Smith 1991. Soil Analysis; Modern Instrumental Techniques. Marcel Dekker.
- Kenneth Helrich 1990. Official Methods of Analysis. Association of Official Analytical Chemists.
- Page AL, Miller RH & Keeney DR. 1982. Methods of Soil Analysis. Part II. SSSA, Madison.
- Piper CE. Soil and Plant Analysis. Hans Publ.
- Singh D, Chhonkar PK & Pandey RN. 1999. Soil Plant Water Analysis – A Methods Manual. IARI, New Delhi.
- Tan KH. 2003. Soil Sampling, Preparation and Analysis. CRC Press/Taylor & Francis.
- Tandon HLS. 1993. Methods of Analysis of Soils, Fertilizers and Waters. FDCO, New Delhi.
- Vogel AL. 1979. A Textbook of Quantitative Inorganic Analysis. ELBS Longman.

5. Compulsory Non-Credit Courses

5.1.Courses' Structure at a Glance

Course Code (ICAR pattern)	Course Code (SGTU pattern)	Course Title	Credits
PGS 501	11060111	LIBRARY AND INFORMATION SERVICES	1(0+1)
PGS 502	11060204	TECHNICAL WRITING AND COMMUNICATIONS SKILLS	1(0+1)
PGS 503	11060205	INTELLECTUAL PROPERTY & ITS MANAGEMENT IN AGRICULTURE (e-Course)	1(1+0)
PGS 504	11060206	BASIC CONCEPTS IN LABORATORY TECHNIQUES	1(0+1)
PGS 505	11060306	AGRICULTURAL RESEARCH, RESEARCH ETHICS & RURAL DEVELOPMENT PROGRAMMES (e-Course)	1(1+0)
PGS 506	11060106	DISASTER MANAGEMENT (e-Course)	1(1+0)

5.1.1 Course Content

11060111: LIBRARY AND INFORMATION SERVICES 1(0+1)

Objective

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

Practical

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

11060204: TECHNICAL WRITING AND COMMUNICATIONS SKILLS 1(0+1)

Objective

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

Practical

Technical writing

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

Communication skills

Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

Suggested Readings

- Robert C. (Ed.). 2005. Spoken English: Flourish Your Language. Abhishek, Chandigarh. Chicago Manual of Style. 14th Ed. 1996. Prentice-Hall of India, New Delhi.
- Collins' Cobuild English Dictionary. 1995. Harper Collins, New York.
- Gibaldi, Joseph. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press, New Delhi.
- Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford UP, Oxford.
- Krishna Mohan 2005. Speaking English Effectively. Macmillan India, New Delhi.
- Mills Gordon H & John A Walter. 1970. Technical Writing. 3rd Ed. Holt, Rinehart & Winston, New York.
- Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice-Hallof India, New Delhi.

- Shelton James H. 1994. Handbook for Technical Writing. NTC Business Books, Chicago. Smith Richard W. 1969. Technical Writing. Barnes & Noble, New York.
- Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand, New Delhi.

11060205: INTELLECTUAL PROPERTY & ITS MANAGEMENT IN AGRICULTURE (e-Course) 1(1+0)

Objective

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

Theory

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

Suggested Readings

- Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI, Wallingford.
- Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw- Hill, New Delhi. India,
- Intellectual Property Rights: Key to New Wealth Generation.2001. NRDC and Aesthetic Technologies, New Delhi.
- Ministry of Agriculture. GoI., 2004. State of Indian Farmer. Vol. 5. Technology Generation and IPR Issues. Academic Foundation.
- Rothschild, Max & Newman, Scott (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
- Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya, Delhi.
- The Indian Acts - Patents Act, 1970 & amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 & amendments; Layout Design Act, 2000; PPV & FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

11060206: BASIC CONCEPTS IN LABORATORY TECHNIQUES 1(0+1)

Objective

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

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and

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

Suggested Readings

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

11060306: AGRICULTURAL RESEARCH, RESEARCH ETHICS & RURAL DEVELOPMENT PROGRAMMES (e-Course) 1(1+0)

Objective

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

Theory

UNIT-I

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

UNIT-II

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

UNIT-III

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

Suggested Readings

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

11060106: DISASTER MANAGEMENT (E-Course) 1(1+0)

Objective

To introduce learners to the key concepts and practices of natural disaster management; to equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building.

Theory

UNIT-I

Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion.

UNIT-II

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

UNIT-III

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations and media. Central, State, District and Local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.

Suggested Readings

- Gupta HK. 2003. *Disaster Management*. Indian National Science Academy. Orient Blackswan.
- Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: A Handbook of Disaster Management*. Routledge.

6. Semester-wise Course Structure

6.1.Course Structure: 1st Semester

Course Code	Course Title	Theory +Practical	L	T	P	Credits
11060113	PRODUCTION TECHNOLOGY OF UNDER-EXPLOITED VEGETABLE CROPS	Theory +Practical	1	0	1	2(1+1)
11060114	SYSTEMATICS OF VEGETABLE CROPS	Theory +Practical	1	0	1	2(1+1)
11060101	TROPICAL AND DRY LAND FRUIT PRODUCTION	Theory +Practical	2	0	1	3(2+1)
11060102	SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION	Theory +Practical	2	0	1	3(2+1)
11060103	POST HARVEST TECHNOLOGY FOR FRUIT CROPS	Theory +Practical	2	0	1	3(2+1)
11060104	CLIMATE MANAGEMENT IN HORTICULTURAL PRODUCTION	Theory	1	0	0	1(1+0)

11060105	ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS	Practical	0	0	2	2(0+2)
11060106	DISASTER MANAGEMENT (E-Course)	Theory	1	0	0	1(1+0)
11060406	MASTER'S RESEARCH	Practical				
11060107	PRINCIPLES OF PLANT PHYSIOLOGY	Theory +Practical	3	0	1	4(3+1)

6.2. Course Structure: 2nd Semester

Course Code	Course Title	Theory +Practical	L	T	P	Credits
11060212	BREEDING OF VEGETABLE CROPS	Theory +Practical	2	0	1	3(2+1)
11060202	PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS	Theory +Practical	2	0	1	3(2+1)
11060213	GROWTH AND DEVELOPMENT OF VEGETABLE CROPS	Theory +Practical	2	0	1	3(2+1)
11060201	BIODIVERSITY AND CONSERVATION OF FRUIT CROPS	Theory +Practical	2	0	1	3(2+1)
11060203	EXPERIMENTAL DESIGNS	Theory +Practical	2	0	1	3(2+1)
11060204	TECHNICAL WRITING AND COMMUNICATIONS SKILLS	Practical	0	0	1	1(0+1)
11060205	INTELLECTUAL PROPERTY & ITS MANAGEMENT IN AGRICULTURE (E-Course)	Theory	1	0	0	1(1+0)
11060206	BASIC CONCEPTS IN LABORATORY TECHNIQUES	Practical	0	0	1	1(0+1)
11060405	MASTER'S SEMINAR	Theory	1	0	0	1(1+0)
11060406	**MASTER'S RESEARCH	Practical				

6.3. Course Structure: 3rd Semester

Course Code	Course Title	Theory +Practical	L	T	P	Credits
11060304	PRODUCTION TECHNOLOGY OF WARM SEASON VEGETABLE CROPS	Theory +Practical	2	0	1	3(2+1)
11060309	FUNDAMENTALS OF PROCESSING OF VEGETABLES	Theory +Practical	1	0	1	2(1+1)
11060301	BREEDING OF FRUIT CROPS	Theory	2	0	1	3(2+1)

		+Practical				
11060302	PROPAGATION AND NURSERY MANAGEMENT FOR FRUIT CROPS	Theory +Practical	2	0	1	3(2+1)
11060303	GAP FOR HORTICULTURAL CROPS	Theory	1	0	0	1(1+0)
11060310	ORGANIC VEGETABLE PRODUCTION TECHNOLOGY	Theory +Practical	1	0	1	2(1+1)
11060111	LIBRARY AND INFORMATION SERVICES	Practical	0	0	1	1(0+1)
11060306	AGRICULTURAL RESEARCH, RESEARCH ETHICS & RURAL DEVELOPMENT PROGRAMMES (E-Course)	Theory	1	0	0	1(1+0)
11060406	**Master's Research	Practical				

6.4. Course Structure: 4th Semester

Course Code (SGTU pattern)	Course Title	Theory +Practical	L	T	P	Credits
11060401	SEED PRODUCTION TECHNOLOGY OF VEGETABLE CROPS	Theory +Practical	2	0	1	3(2+1)
11060406	**MASTER'S RESEARCH	Practical				

7. E- Resources for Information on Horticulture

1. Agricultural & Processed Food Products Export Development Authority (APEDA) <http://www.apeda.com/>
2. American Society for Horticultural Science <http://www.ashs.org/> Asian Vegetable Research and Development Center (AVRDC) <http://www.avrdc.org.tw/>
3. Australian Society for Horticultural Science <http://www.aushs.org.au/>
4. Central Food Technological Research Institute (CFTRI) <http://www.cftri.com/>
5. Central Institute of Medicinal & Aromatic Plants (CIMAP) <http://www.cimap.org/>
6. Central Institute of Post-harvest Engineering and Technology <http://www.icar.org.in/ciphet.html>
7. Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala <http://cpcri.nic.in/>
8. Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala <http://www.ctcri.org/>
9. Consultative Group on International Agricultural Research, CGIAR <http://www.cgiar.org/>
10. Coffee Board, India <http://indiacoffee.org/> Department of Agriculture and Co-operation, India <http://agricoop.nic.in/>
11. Department of Bio-technology, India <http://dbtindia.nic.in> Department of Scientific and Industrial Research, India <http://dsir.nic.in/>

12. FAO <http://www.fao.org/>Global Agribusiness Information Network:<http://www.fintrac.com/gain/>:
13. Greenhouse Vegetable Information: <http://www.ghvi.co.nz/>
14. Indian Agricultural Research Institute (IARI) <http://www.iari.res.in/>
15. Indian Council of Agricultural Research (ICAR) <http://www.icar.org.in>
16. Indian Institute of Horticultural Research (IIHR) www.iihr.res.in
17. Indian Institute of Spices Research (IISR), Calicut, Kerala <http://www.iisr.org/>
18. Indo-American Hybrid Seeds www.indamseeds.com
19. Institute of Vegetable and Ornamental Crops <http://www.igzev.de/>
20. Institute for Horticultural Development, Victoria, Australia <http://www.nre.vic.gov.au/agvic/ih/>
21. Kerala Agricultural University www.kau.edu
22. Iowa State University, Department of Horticulture <http://www.hort.iastate.edu/>
23. National Bureau of Plant Genetic Resources (NBPGR), India <http://nbpgr.delhi.nic.in/>
24. National Horticulture Board (NHB), India <http://hortibizindia.nic.in/>
25. National Institute of Agricultural Extension Management (MANAGE), India <http://www.manage.gov.in/>
26. National Research Centre for Cashew (NRCC), <http://kar.nic.in/cashew/India>
27. National Research Centre for Mushroom (NRCM), India <http://www.nrcmushroom.com/>
28. National Research Centre for Oil Palm (NRCOP), India <http://www.ap.nic.in/nrcop>
29. North Carolina State University, Dept. of Horticulture http://www2.ncsu.edu/cals/hort_sci/
30. Oregon State University, Dept. of Horticulture <http://osu.orst.edu/dept/hort>
31. Pineapple News <http://agrss.sherman.hawaii.edu/pineapple/pineappl.htm>
32. Pomology Resources Center [http://www.bsi.fr/pomologie/english/pomology:Rubberboard, India](http://www.bsi.fr/pomologie/english/pomology:Rubberboard,India) <http://rubberboard.org.in/>
33. Spice Paprika web site <http://www.paprika.deltav.hu/>:
34. Spices Board, India <http://www.indianspices.com/>
35. Sri Lanka Agri-business on-line <http://www.agro-lanka.org/>
36. Sustainable Apple Production: <http://orchard.uvm.edu/>
37. Tea Board, India <http://tea.nic.in/>
38. The Horticultural Taxonomy Group <http://www.hortax.org.uk/>
39. The International Society of Citriculture: http://www.lal.ufl.edu/isc_citrus_homepage.htm
40. The Internet Garden <http://www.internetgarden.co.uk/>
41. The Rose Resource <http://rose.org/>
42. The USDA Agricultural Research Service <http://www.ars.usda.gov/>
43. University of Florida, Dept. of Environmental Horticulture <http://hort.ifas.ufl.edu/>
44. University of California, Fruit & Nut Research <http://fruitsandnuts.ucdavis.edu/>
45. US Environmental Protection Agency <http://www.epa.gov/>:
46. USDA <http://www.usda.gov/>
