

22 Seed Science and Technology

TRIMESTER WISE DISTRIBUTION OF COURSES

I TRIMESTER

	L	P
SST 501 FLORAL BIOLOGY, SEED DEVELOPMENT & MATURATION	2	1
SST 502 SEED PRODUCTION: PRINCIPLES AND PRACTICES	3	2
SST 510/ SEED HEALTH TECHNOLOGY PATH 510	3	2
SST 513 SEED STORAGE AND DETERIORATION	2	1
SST 601 HYBRID SEED PRODUCTION	2	2
SST 604 DUS TESTING FOR PLANT VARIETY PROTECTION	2	1
SST 691 SEMINAR	1	0

II TRIMESTER

AGR 012 BASICS OF SEED TECHNOLOGY	1	1
SST 503 SEED PRODUCTION IN FIELD CROPS	2	1
SST 506 SEED LEGISLATION AND CERTIFICATION	3	1
SST 508 SEED QUALITY TESTING	3	2
SST 511/ PRINCIPLES AND TECHNIQUES IN VEGETABLES SEED PRODUCTION VSC 511	4	1
SST 514 SEED MARKETING AND MANAGEMENT	2	1
SST 516 PLANT QUARANTINE	2	0
SST 603 TESTING FOR GENUINENESS AND PURITY OF CULTIVERS	2	2
SST 691 SEMINAR	1	0

III TRIMESTER

SST 512 SEED PRODUCTION IN PASTURE, FORAGE AND GREEN MANURE CROPS	2	1
SST 515 EMERGING TRENDS IN SEED QUALITY ENHANCEMENT	2	1
SST 517 SEED ENTOMOLOGY	1	1
SST 521/ PLANTING MATERIAL AND SEED PRODUCTION IN FLOWER CROPS FLA 521	2	1

SST 543/ SEED PROCESSING AE 543	2	1
SST 605 ADVANCES IN SEED SCIENCE RESEARCH	2	0
SST 608/ PHYSIOLOGY OF SEEDS PP 608	2	1
ST 691 SEMINAR	1	0

Core Courses

M.Sc.: SST 501, SST 502, SST 506, SST 508, and SST 510

Ph. D.: SST 601, SST 604

SEED SCIENCE AND TECHNOLOGY

Major Field : Seed Science and Technology

Minor Field : Ph.D. student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AGR 012 BASICS OF SEED TECHNOLOGY

(1L+1P) II

Objective

To provide basic knowledge of seed science & technology required for understanding the techniques of seed production in crops and seed quality measurement.

Theory

UNIT I

Seed as a basic input in agriculture, seed development in cultivated plants; classification of crop plants in relation to mode of reproduction; concept and importance of genetic purity in seed production; seed production in self- and cross- pollinated crops.

UNIT II

Seed certification principles, purpose and procedure and identification of crop varieties.

UNIT III

Seed testing, seed sampling, physical and genetic purity, seed germination and vigour, moisture testing and use of tolerance test in seed testing. Seed storage behavior and desiccation tolerance.

Practicals

Visit of seed production plots of field crops and vegetables. Seed quality measurement viz. physical and genetic purity testing, identification of weed seeds, germination and vigour testing, moisture testing and seed health testing.

Suggested Readings

Agarwal, R.L. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.

Desai, B.B. 2004. *Seeds Handbook*. Marcel Dekker.

Kelly, A.F. 1988. *Seed Production of Agricultural Crops*. Longman.

McDonald, M.B. Jr and Copeland, L.O. 1997. *Seed Production: Principles and Practices*. Chapman and Hall.

Musil, A.F. 1967. *Identification of Crop and Weed Seeds*. Handbook No. 219, USDA, Washington, DC, USA.

Singhal, N.C. 2003. *Hybrid Seed Production in Field Crops*. Kalyani Publishers, N. Delhi.

Thompson, J.R. 1979. *An Introduction to Seed Technology*. Leonard Hill.

Tunwar, N.S. and Singh, S.V. 1988. *Indian Minimum Seed Certification Standards*. CSCB, GOI.

Objective

To refresh the basic knowledge of seed development and structures and apprise students with its relevance to production of quality seed.

Theory

UNIT I

Floral types, structure and biology in relation to pollination mechanisms; sporogenesis: micro-sporogenesis and mega-sporogenesis; micro and mega gametogenesis - development of male and female gametes and their structures; effect of environmental factors on floral biology.

UNIT II

Fertilization – embryo sac structure, process, barriers to fertilization, incompatibility and male sterility, factors affecting fertilization.

UNIT III

Embryogenesis - development of typical monocot and dicot embryos; endosperm development, modification of food storage structures with reference to crop plants; different types of embryos, endosperm and cotyledons; development and their structure in representative crop plants with reference to food storage; external and internal features of monocot and dicot seed; seed coat structure and development in representative crop plants.

UNIT IV

Apomixis – identification, classification, significance and its utilization in different crops for hybrid seed production; Polyembryony - types and significance; haplontic and diplontic sterility, causes of embryo abortion, embryo rescue and synthetic seeds.

Practicals

Study of floral biology of monocots and dicots; micro-sporogenesis and mega-sporogenesis; study of pollen grains - pollen morphology, pollen germination and pollen sterility; types monocot and dicot embryos; external and internal structures of monocot and dicot seeds; seed coat structure, preparation of seed albums and identification.

Suggested Readings

- Bhojwani, S.S. and Bhatnagar, S.P. 1999. *The Embryology of Angiosperm*. Vikas Publ.
- Black, M., Bewley, D. and Halmer, P. 2006. *The Encyclopedia of Seeds: Science, Technology and Uses*. CABI.
- Chhabra, A.K. 2006. *Practical Manual of Floral Biology of Crop Plants*. Deptt. of Plant Breeding, CCS HAU, Hisar.
- Copeland, L.O. and McDonald, M.B. 2001. *Principles of Seed Science and Technology*. 4th Ed. Chapman & Hall.
- Frankel, R. and Galun, E. 1977. *Pollination Mechanisms, Reproduction and Plant Breeding*. Springer Verlag.

Objective

To introduce the basic principles of quality seed production.

Theory

UNIT I

Seed as a basic input in agriculture, quality concept and importance of genetic purity in seed production; life span of varieties and factors responsible for their deterioration.

UNIT II

Steps in the development, evaluation, release, notification and maintenance of varieties; classification of crop plants in relation to the mode of reproduction and its modification for hybrid seed production.

UNIT III

Principles of hybrid seed production viz. isolation, synchronization of flowering, field inspection, roguing etc.; special agronomical practices for seed production and effect of environment before harvest on seed quality; male sterility and self incompatibility in hybrid seed production, role of insect pollinators and their management for hybrid seed production, ecology and dynamics of pollinators.

UNIT IV

Seed quality control system and organization, suitable seed production areas, seed village concept; agencies responsible for seed production, seed industry in India, custom seed production, role of seed growers and seed producers in hybrid seed production.

Practicals

Seed production in rice and maize (varieties and hybrids), pollination in hybrid seed production plots of rice and maize, visit to Bajra and cotton seed production plots, visit to vegetable seed production field, hybrid seed production in cauliflower. Emasculation and pollination in bitter gourd and brinjal. Visit to seed production companies and certification agencies. Visit to seed processing units.

Suggested Readings

Agarwal, R.L. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.

Chhabra, A.K. 2006. *Practical Manual of Floral Biology of Crop Plants*. Dept. of Plant Breeding CCS HAU, Hisar.

Desai, B.B. 2004. *Seeds Handbook*. Marcel Dekker.

Kelly, A.F. 1988. *Seed Production of Agricultural Crops*. Longman.

Mc Donald, M.B. Jr and Copeland, L.O. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.

Musil, A.F. 1967. Identification of Crop and Weed Seeds. Handbook No. 219, USDA, Washington, DC, USA.

Poehlman, J.M. and Sleper, D.A. 2006. *Breeding Field Crops*. Blackwell.

Singh, B.D. 2005. *Plant Breeding: Principles and Methods*. Kalyani Publishers.

- Singhal, N.C. 2003. *Hybrid Seed Production in Field Crops*. Kalyani Publishers.
- Thompson, J.R. 1979. *An Introduction to Seed Technology*. Leonard Hill.
- Tunwar, N.S. and Singh, S.V. 1985. *Handbook of Cultivars*. CSCB, GOI.

SST 503 SEED PRODUCTION IN FIELD CROPS

(2L +1P) II

(Pre-requisite SST 502)

Objective

To impart a comprehensive knowledge of seed production in field crops with adequate practical training.

Theory

UNIT I

Basic principles in seed production and importance of quality seed. Floral structure, breeding and pollination mechanism in self-pollinated cereals and millets viz, wheat, barley, paddy, ragi etc.

UNIT II

Floral structure, breeding and pollination mechanism in cross-pollinated cereals and millets viz maize, sorghum, bajra etc; methods and techniques of quality seed production in cross-pollinated cereals and millets.

UNIT III

Floral structure, breeding and pollination mechanism; methods and techniques of seed production in pulses (pigeon pea, chick pea, green gram, black gram, field beans, peas etc.).

UNIT IV

Floral structure, breeding and pollination mechanism; methods and techniques of seed production in major oil seeds (groundnut, castor, sunflower, safflower, rape and mustard, linseed, sesame etc.).

UNIT V

Floral structure, breeding and pollination mechanism; methods and techniques of seed production in commercial fibers (cotton, jute, mesta etc) and vegetatively propagated crops like sugar cane, potato etc.

Practicals

Planning of Seed Production, requirements for different classes of seeds in field crops - unit area and rate; Seed production in cross pollinated crops with special reference to land, isolation, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony; supplementary pollination, pollen storage, hand emasculation and pollination in cotton, detasseling in corn, identification of rogues and pollen shedders; Pollen collection, storage, viability and stigma receptivity; gametocide application and visits to seed production plots etc.

Suggested Readings

- Kelly, A.F. 1988. *Seed Production of Agricultural Crops*. John Wiley.
- McDonald, M.B. Jr and Copeland, L.O. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.
- Singhal, N.C. 2003. *Hybrid Seed Production in Field Crops*. Kalyani Publishers.

Objective

To apprise students with the legislative provisions and processes and the mechanisms of seed quality control.

Theory

UNIT I

Historical development of Seed Industry in India; Seed quality: concept and factors affecting seed quality during different stages of production, processing and handling; seed quality control- concept and objectives; Central Seed Certification Board (CSCB).

UNIT II

Regulatory mechanisms of seed quality control- organizations involved in seed quality control programmes; seed legislation and seed law enforcement as a mechanism of seed quality control; the Seed Act (1966), Seed Rules (1968), Seed (Control) Order 1983; Essential Commodities Act (1955); Plants, Fruits and Seeds Order (1989); National Seed Development Policy (1988) and EXIM Policy regarding seeds, plant materials; New Seed Bill-2004 etc. Introduction, objectives and relevance of plant quarantine, regulations and plant quarantine set up in India.

UNIT III

Seed Certification- history, concept and objectives of seed certification; seed certification agency / organization and staff requirement; legal status and phases of seed certification; formulation, revision and publication of seed certification standards; Indian Minimum Seed Certification Standards (I.M.S.C.S.) general and specific crop standards including GM varieties, field and seed standards; planning and management of seed certification programmes- eligibility of a variety for certification, area assessment, cropping history of the seed field, multiplication system based on limited generation concept, isolation and land requirements etc.

UNIT IV

Field Inspection- principles, phases and procedures; reporting and evaluation of observations; pre and post-harvest control tests for genetic purity evaluation (grow-out tests); post harvest inspection and evaluation; seed sampling, testing, labeling, sealing and grant of certificate; types and specifications for tags and labels; maintenance and issuance of certification records and reports; certification fee and other service charges; training and liaison with seed growers. OECD seed certification schemes.

UNIT V

Introduction to WTO and IPRs; Plant Variety Protection and its significance; UPOV and its role; DUS testing- principles and applications; essential features of PPV & FR Act, 2001 and related Acts.

Practicals

General procedure of seed certification ; identification of weed and other crop seeds as per specific crops; field inspection at different stages of a crop and observations recorded on contaminants and reporting of results; inspection and sampling at harvesting / threshing, processing and after processing for seed law enforcement; testing physical purity, germination and moisture; specifications for tags and labels to be used for certification purpose; grow-out tests for pre and post-harvest quality control; visits to regulatory seed testing laboratory, including plant quarantine lab and seed certification agency.

Suggested Readings

Agarwal, R.L. 1997. *Seed Technology*. Oxford & IBH.

Anonymous. 1992. *Legislation on Seeds*. NSC Ltd., Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi.

Nema, N.P. 1986. *Principles of Seed Certification and Testing*. Allied Publishers.

Tunwar, N.S. and Singh, S.N. 1988. *Indian Minimum Seed Certification Standards*. CSCB, Ministry of Agriculture, New Delhi.

SST 508 SEED QUALITY TESTING

(3L + 2P) II

Objective

To provide a comprehensive knowledge on all aspects of seed quality evaluation and their relevance to crop performance.

Theory

UNIT I

Introduction: Structure of monocot and dicot seeds; seed quality: objectives, concept and components and their role in seed quality control; instruments, devices and tools used in seed testing. ISTA - and its role in seed testing. Seed Sampling: definition, objectives, seed-lot and its size; types of samples; sampling devices; procedure of seed sampling; sampling intensity; methods of preparing composite and submitted samples; sub-sampling techniques, dispatch, receipt and registration of submitted sample in the laboratory, sampling in the seed testing laboratory.

UNIT II

Physical Purity: definition, objective and procedure, weight of working samples for physical purity analysis; components of purity analysis and their definitions and criteria; pure seed definitions applicable to specific genera and families; multiple seed units; general procedure of purity analysis; calculation and reporting of results, prescribed seed purity standards; determination of huskless seeds; determination of weed seed and other seed by number per kilogram; determination of other distinguishable varieties (ODV); determination of test weight and application of heterogeneity test.

UNIT III

Seed moisture content: importance of moisture content; equilibrium moisture content; principles and methods of moisture estimation - types, instruments and devices used; pre-drying and grinding requirements, procedural steps in moisture estimation; calculation and reporting of results.

UNIT IV

Germination: importance; definitions; requirements for germination, instrument and substrata required; principle and methods of seed germination testing; working sample and choice of method; general procedure for each type of method; duration of test; seedling evaluation; calculation and reporting of results; dormancy: definition, importance, causal mechanisms, types and methods for breaking dormancy. Viability and vigour testing: definition and importance of viability tests; different viability tests; quick viability test (TZ- test) - advantages, principle, preparation of seeds and solutions, procedure, evaluation and calculation of test results. Vigour testing: concept, historical development, definitions, principles and procedures of different methods used for testing vigour.

UNIT V

Genetic purity testing: objective and criteria for genetic purity testing; types of test; laboratory, growth chamber and field testing based on seed, seedling and mature plant morphology; principles and procedures of chemical, biochemical and molecular tests.

UNIT VI

Seed health Testing: field and seed standards ; designated diseases, objectionable weeds - significance of seed borne disease vis-a-vis seed quality - seed health testing and detection methods for seed borne fungi, bacteria, viruses and nematodes. Testing of GM seeds and trait purity, load of detection (LOD). Preparation and dispatch of seed testing reports; storage of guard samples; application and use of seed standards and tolerances.

Practicals

Structure of monocot and dicot seeds of important plant species; identification and handling of instruments used in seed testing laboratory; identification of seeds of weeds and crops; physical purity analysis of samples of different crops; estimation of seed moisture content (oven method); seed dormancy breaking methods requirements for conducting germination test, specifications and proper use of different substrata for germination; seed germination testing in different agricultural crops; seedling evaluation; viability testing by tetrazolium test in different crops; seed and seedling vigour tests applicable in various crops; species & cultivar identification; genetic purity testing by chemical, biochemical and molecular methods; seed health testing for designated diseases, blotter methods, agar method and embryo count methods; testing coated / pelleted seeds.

Suggested Readings

Agarwal, R.L. 1997. *Seed Technology*. Oxford & IBH.

Agrawal, P.K. and Dadlani, M. 1992. *Techniques in Seed Science and Technology*. 2nd Ed. South Asian Publ.

Agrawal, P.K. (Ed.). 1993. *Handbook of Seed Testing*. Ministry of Agriculture, GOI, New Delhi.

Copland, L.O. and McDonald, M.B. 1996. *Principles of Seed Science and Technology*. Kluwer.

ISTA. 2006. *Seed Testing Manual*. ISTA, Switzerland.

Martin, C. and Barkley, D. 1961. *Seed Identification Manual*. Oxford & IBH.

Tunwar, N.S. and Singh, S.V. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

SST 510 / PATH 510 SEED HEALTH TECHNOLOGY

(3L+2P) I

Objective

To acquaint the students with principles and practices of seed health testing and management of seed borne diseases.

Theory

UNIT I

History and economic importance of the seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical noncotyledonous and dicotyledonous infected seeds.

UNIT II

Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogen.

UNIT III

Seed certification and tolerance limits, types of losses caused by seed borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed borne pathogens. Epidemiological factors influencing the transmission of seed borne diseases, forecasting of epidemics through seed borne infection.

UNIT IV

Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed borne pathogen / diseases and procedure for healthy seed production, seed health testing, methods for detecting micro-organism.

Practicals

Conventional and advance technique in the detection and identification of seed –borne fungi, bacteria and viruses. Relationship between seed borne infection and expression of the disease in the field.

Suggested Readings

Agarwal, V.K. and Sinclair, J.B. 1997. *Principles of Seed Pathology*. Boca Raton.

Karuna, V. 2007. *Seed Health Testing*. Kalyani.

Neergaard, P. 1988. *Seed Pathology*. Mac Millan.

SST 511 / VSC 511 PRINCIPLES AND TECHNIQUES OF VEGETABLES SEED PRODUCTION (4L +1P) II

Objective

To impart a comprehensive knowledge of seed production in vegetable crops with adequate practical training

Theory

UNIT-I

Importance and present status of vegetable seed industry; intellectual property rights and their implications; new seed policies; DUS testing principles and procedure; impact of PVP on growth of seed industry.

UNIT-II

Genetical and agronomical principles of seed production; categories of seed and their maintenance; seed certification; seed standards; seed act; plant quarantine and quality control

UNIT-III

Seed morphology and development in vegetable seeds; agro-techniques for vegetable seed production; environmental factors related to flowering/bolting in vegetable crops; floral biology; pollination systems and breeding techniques related to vegetable seed production in different crops; isolation distances; roguing; selection procedures and criteria for seed production; hybrid seeds; seed extraction methods; maintenance breeding in vegetable crops.

Practicals

Field visit to division of vegetable science and seed science & technology and CPCT. Seed production technology of cucurbits, solanaceous vegetables and cole crops in open, under poly-house & low tunnel. Crossing & emasculation and pollination systems in different vegetable crops. Seed production techniques of cauliflower, peas, French bean, winter bean, *Dolichos* bean, okra, onion, brinjal, chilli, capsicum, carrot, turnip, and radish. Floral biology, determining of planting ratios for hybrid seed production and maintenance of varieties and parental lines.

Suggested Reading:

- George, Raymond A.T. 1999. *Vegetable Seed Production*. CABI. Publishing, New York
- Singh, S.P. 2001. *Seed Production of Commercial Vegetables*. Agrotech Publishing Academy, New Delhi
- Basra, A.S. 2000. *Hybrid Seed Production in Vegetables*. CRC Press, FL, USA
- Salunkhe, D.K., Desai, B.B. and Bhat, N.R. 1987. *Vegetable and Flower Seed Production*. Agricole Publishing Academy, New Delhi
- Agarwal, R.L. 1996. *Seed Technology*. Oxford, IBH Publishing Co., New Delhi.
- Desai, B.B., Katecha, P.M. and Salunke, D.K. 1997. *Seed Hand Book: Biology, Production, Processing and Storage*. Marcel Dekker.
- Kelly, A.F. and George, R.A.T. (Eds.). 1998. *Encyclopedia of Seed Production of World Crops*. John Wiley & Sons.

SST 512 SEED PRODUCTION IN PASTURE, FORAGE AND GREEN MANURE CROPS

(2L +1P) III

Objective

To apprise about the basic requirements and methods of quality seed production in forage, pasture and green manure crops.

Theory

UNIT I

Important pasture and forage legume crops in India; seed requirement and production; classification of forage, pastures and green manure crops; pollination behavior.

UNIT II

Factors influencing seed production; maintenance of varietal purity, generation systems of seed multiplication self pollinated crops; seed production in apomictic grasses.

UNIT III

Methods and techniques of seed production in important grasses, pastures, legumes and green manure crops; apomictic seed.

UNIT IV

Selection of seed production areas, influence of season, seed rate and spacing, sowing methods, direct seed sowing, transplanting, pelleting, fertilizer and manure requirement, isolation distance, weed control, pollination and seed setting, seed shattering, seed maturity and stage of harvest, seed collection, economics of seed production of important fodder crops.

UNIT V

Seed processing, seed treatment, seed storage, seed viability of grasses and leguminous crops.

Practicals

Study of flower structure, seed collection and identification, characteristics of forage, pastures and green manure crops; maturity indices for harvest, seed testing- sampling, purity, moisture, germination and dormancy, seed treatments.

Suggested Readings

Loch, D.S. and Ferguson, J.E. 1997. *Forage Seed Production*. Vol. II. *Tropical and Sub-tropical species*. CABI.

Humphreys, L.R. and Riveros, F. 1986. *Tropical Pasture Seed Production*, 3rd Edn. FAO Plant Production and Protection Paper 8, Rome

Singh, Panjab 1988. *Pasture and Forage Crop Research – A State of Knowledge*. RMSI, IGFRI, Jhansi, UP.

Skerman, P.J. and Riveros, F. 1990. *Tropical Grasses*. FAO Rome

SST 513 SEED STORAGE AND DETERIORATION

(2L +1P) I

Objective

To provide understanding of the mechanism of seed ageing during storage, factors affecting it and its control.

Theory

UNIT I

Life span of seeds of plant species; classification of seeds on the basis of storage behaviour; orthodox and recalcitrant seeds; types of storage; kinds of seed storage (open, bulk, controlled, hermetic, germplasm, cryopreservation); soil seed bank; terminology; survival curve of seed.

UNIT II

Factors affecting seed storability- biotic and abiotic and pre- and post harvest factors affecting seed longevity; the effects of packaging materials, storage fungi and insects, seed treatment and fumigation and storage environmental conditions on seed storability; moisture equilibrium in seeds; hysteresis effect; thumb rules; selection of suitable areas/places for safe storage; prediction of relative storability and longevity of seed lots, viability equations and nomographs.

UNIT III

Concept of seed ageing and deterioration, its causes, symptoms, mechanisms and related theories; different changes associated with the loss of vigour and viability during storage; application of physiological and biochemical techniques for evaluation of seed ageing; genetics of seed viability; effect of seed ageing on crop performance; maintenance of viability and vigour during storage; seed amelioration techniques, mid storage corrections etc.

UNIT IV

Storage methods- requirement of storage facilities in India; types and storage structures available in the country and their impact on short and long term storage; methods of safe seed storage including eco-friendly techniques used in various group of crops viz. cereals, pulses, oilseeds, fibers,

forages and vegetables; operation and management of seed stores; fruit storage; viability loss during transportation and interim storage.

Practicals

To study the effect of storage environmental factors (RH, SMC and temperature) on seed longevity; to study the effect of packaging materials, seed treatment and fumigation on storability; prediction of storability and longevity of seed-lots by using viability equations and nomographs; standardization of accelerated ageing (AA) technique for assessing the seed storability of various crops; estimation of carbohydrates, proteins, fats, enzyme activities, respiration rate and nucleic acids in fresh and aged seeds; use of eco-friendly products and amelioration techniques to enhance quality of stored seeds, visit to seed stores.

Suggested Readings

- Barton, L.V. 1961. *Seed Preservation and Longevity*. Burgess Publ.
- Basra, A.S. (Ed.). 1995. *Seed Quality: Basic Mechanisms and Agricultural Implications*. Food Products Press.
- Basra, A.S. 2006. *Handbook of Seed Science and Technology*. Food Product Press.
- Desai, B.B. 2007. *Seed Handbook: Biology, Production, Processing and Storage*. Marcel Dekker.
- Doijode, S.D. 2001. *Seed Storage of Horticultural Crops*. CBS.
- Justice, O.L. and Bass, L.N. 1978. *Principles and Practices of Seed Storage*. Castle House Publ.
- Kharb, R.P.S. and Kharb, P. 1977. Biochemical and cytogenetical changes during storage. In: *Seed Technology* (Eds. BS Dahiya & KN Rai): pp. 160-168.
- Roberts, E.H. 1972. *Viability of Seeds*. Chapman & Hall.

SST 514 SEED MARKETING AND MANAGEMENT

(2L +1P) II

Objective

To apprise students about the seed supply system, concepts and principles of effective marketing of seed and strengths and weaknesses of the seed sector.

Theory

UNIT I

Importance and promotion of quality seed, formal and informal seed supply systems. Basic concepts of marketing with special reference to seed; importance and scope of seed industry in India, major constraints/problems in seed industry/seed sector role of seed association / federation in seed trade.

UNIT II

Demand and supply of seed; Role of seed replacement rate (SRR), seed multiplication ratio (SMR), cost of production and returns; determining seed needs; seed pricing and price policy, seed processing and / packaging, demand forecasting.

UNIT III

Seed marketing intelligence and product mix, sales promotion, distribution channels, marketing costs and margins.

UNIT IV

Salient features of national seed policies, role of various sectors/agencies in efficient seed marketing, quality control and assurance programme. Responsibilities of seed companies and dealers under Seed Act, EXIM policies for seed trade etc.

Practicals

Statutory requirements in seed business including R&D, estimation of cost of seed production, marketing costs and margins of seeds of different crops, case studies to compare public & private sectors in different conditions, impact analysis., seed pricing, cost benefit ratio, economic feasibility of seed industry etc.

Suggested Readings

Kohls, R.L. and Uhl, J.N. 1980. *Marketing of Agricultural Products*. MacMillan.

Kundu, K.K. and Suhag, K.S. 2006. *Teaching Manual on Seed Marketing and Management*. Department of Agricultural Economics CCS HAU Hisar.

Venugopal, P. 2004. *State of Indian Farmers: A Millennium Study*. Vol. VIII. *Input Management*. Academic Foundation, Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi.

SST 515 EMERGING TREND IN SEED QUALITY ENHANCEMENT

(2L+1P) III

Objective

To update knowledge on seed quality enhancement technologies and their application.

Theory

UNIT I

Concept and significance of seed quality enhancement; physical, chemical and pesticidal seed treatments, history, principles and methods of seed treatment, methodology and factors affecting seed enhancement treatments.

UNIT II

Seed priming: physiological and biochemical basis, types of priming technology, biochemical and molecular changes associated, pre-germination, film coating and pelleting, seed tapes, seed mats, seed colouring, biopriming.

UNIT III

Synthetic seeds – Aim and scope for synthetic seeds, historical development, somatic embryogenesis, somaclonal variation and their control, embryo encapsulation systems, hardening of artificial seeds, cryo-preservation, storage of artificial seeds, desiccation tolerance, use of botanicals in improving seed quality etc.

Practicals

Seed treatments – methods and techniques, equipments required for seed treatment, film coating; seed invigoration /priming - hydration and dehydration, PEG priming, solid matrix priming, bio priming, effects of priming; methods for hydrogel encapsulation of artificial endosperm, hydrophobic coating etc.; protocols for production of synthetic seeds, Visit to leading Seed Companies to study the seed treatment processes.

Suggested Readings

- Basra, A.S. (Ed.). 1995. *Seed Quality: Basic Mechanisms and Agricultural Implications*. Food Product Press, NY.
- Basra, A.S. 2006. *Handbook of Seed Science and Technology*. Food Product, Press, NY
- Bench, A.L.R. and Sanchez, R.A. 2004. *Handbook of Seed Physiology*. Food Product Press, NY/ London.
- Copland, L.O. and McDonald, M.B. 2004. *Seed Science and Technology*. Kluwer Acad.
- Kaloo, G., Jain, S.K., Vari, A.K. and Srivastava, U. 2006. *Seed: A Global Perspective*. Associated Publishing Company, New Delhi.

SST 516 PLANT QUARANTINE

(2L+0P) II

Objective

To apprise students about the economic significance of plant quarantine, principles and concepts, and plant quarantine operations in Indian context.

Theory

UNIT I

History and economic significance of plant quarantine; principles and concepts; scope and prospects; plant quarantine operations in Indian context.

UNIT II

New policy on seed development in India; international spread of seed-borne diseases due to export & import; pest risk analysis concept in plant quarantine; role of plant quarantine in preventing and / checking the spread of insect & plant pathogen, nematodes.

UNIT III

Export & import plant quarantine; domestic quarantine, its weakness and measures for its strengthening; plant protection convention and international cooperation in plant quarantine; problems in assessing the overall effectiveness of plant quarantine; techniques for the detection of insects/mites, nematodes, fungal and bacterial pathogens, viruses and salvaging of infested / infected germplasm.

Suggested Readings

- Muthaiyan, M.C. 1998. *Principles and practices of Plant Quarantine*. Allied Publishers
- Agarwal, V.K. and Sinclair, J.B. 1997. *Principles of Seed Pathology*. Boca Raton.

SST 517 SEED ENTOMOLOGY

(1L + 1P) III

Objective

To apprise about the role of insects in seed production and their effect on seed quality during storage.

Theory

UNIT I

Principles of seed entomology; pollinator insects, insect pests and their classification based on mode of infestation etc.

UNIT II

Principles of insect pollination, role of pollinators in seed Production. Augmenting quality seed production through honeybee pollination in crucifers and forage legumes. Plant protection measures in bee pollinated crops. Management of pollinators for hybrid seed production.

UNIT III

Major insect pests of principal crops and their management practices. Methods of insect pest control. Classes of pesticides, their handling and safe use on seed crops.

UNIT IV

Storage insect pests infecting seeds, their development and economic importance. Storage losses due to pests, control of storage pests, Management of storage insects pests, mites and rodents, seed sampling and loss estimation.

UNIT V

Principles of fumigation and their use, effect of different fumigants; preservatives and seed protectants on seed quality; Type of storage structures – domestic and commercial.

Practicals

Collection and identification of insect-pollinators, collection and identification of important pests of stored seeds. Detection and estimation of pest infestation vis- a- vis loss of seed quality. Safe handling and use of fumigants and insecticides; safety measures in fumigating and disinfecting, exposure period, aeration etc. the storage structures. Plant protection equipments, their operation and maintenance. Pesticides, its dose determination, preparation of solution and its application.

Suggested Readings

- Agarwal, N.A. and Girish, G.K. 1977. *An Introduction to Action Programme to Regress on Farm Storage Losses in India*. FAO/NORAD Seminar on Farm Storage Grain in India, Nov. 29-Dec. 8, 1977.
- Anderson, J.A. and Aleock, A.W. 1954. *Storage of Cereal Grain & their Products*. American Assoc. Cereal Chemists, St. Pauls, Minn.
- Cottong, R.T. 1963. *Insect Pests of Stored Grain and Grain Products*. Burgess Publ. Co., Minneapolis, Minn., USA.
- Monro. 1969. *Manual of Fumigation for Insect Control*. FAO Rome Agril. Studies No. 79.
- Subramanyam, B. and Hagstrum, D.W. 1995. *Interrelated Management of Insects in Stored Products*. Marcel Dekker.

SST 521 / FLA 521 PLANTING MATERIAL AND SEED PRODUCTION IN FLOWER CROPS (2L+1P) III

Objective

To impart basic knowledge about the importance of planting material and production of seed in important flower crops grown in India.

Theory

UNIT I

Scope and importance of planting material in flower crops;

UNIT II

Global and Indian scenario in planting material and flower seed production, propagation techniques, nursery management,

UNIT III

Propagation structures, sanitary and phyto-sanitary issues, plug plant production, nursery standards, Hi-tech nurseries micropropagation of ornamental plants,

UNIT IV

F1 hybrid seed production advantages, steps involved in hybrid seed production, methods in production of F1 hybrids in different flowers like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum etc., pollination behavior and isolation, pollination management,

UNIT V

Use of incompatibility, use of male sterility, maintenance of variety, seed production in open pollinated crops.

Practicals

Demonstration of propagation techniques; Nursery management techniques; Plug plant production; Steps involved in hybrid seed production; Hybrid seed production in different flower crops like marigold, petunia, antirrhinum, zinnia, pansy, lupin, calendula, phlox, vinca, dianthus, sunflower, annual chrysanthemum etc

Suggested Readings

Bhattacharjee, S.K. 2006. *Advances in Ornamental Horticulture*. Vols. I-VI. Pointer Publ.

Hartmann, H.T., Kester, D.E., Davies, F.T. and Geneve, R.L. 2002. *Hartmann and Kesters's Plant Propagation: Principles and Practices*, 7th edn. Prentice Hall of India, New Delhi.

Bose, T.K., Yadav, L.P., Pal, P., Parthasarathy, V.A. and Das, P. 2003. *Commercial Flowers. Vol. I and II*. Naya Udyog, Kolkata.

Larson, R.A. 1992. *Introduction of Floriculture*. International Book Distributing Co., Lucknow

SST 543 / AE 543 SEED PROCESSING

(2L +1P) III

Objective

To impart knowledge on the principles and techniques of seed processing for quality upgradation and of storage for maintenance of seed quality.

Theory

UNIT I

Introduction: Principles of seed processing; methods of seed drying including dehumidification and its impact on seed quality. Relative humidity and equilibrium moisture content of seed; Thumb rules of seed storage; loss of viability in important agricultural and horticultural crops, viability equations and application of nomograph.

UNIT II

Seed cleaning equipment and their functions: Preparing seed for processing; functions of scalper debearder, scarifier, huller, seed cleaner and grader. Screen cleaners, specific gravity separator, indented cylinder, velvet-spiral-disc separators, colour sorter, delinting machines; seed blending.

UNIT III

Assembly line of processing and storage, receiving, elevating and conveying equipments, plant design and layout, requirements and economic feasibility of seed processing plant.

UNIT IV

Seed treatments-methods of seed treatment, seed treating formulations and equipments, seed disinfestations, identification of treated seeds; Packaging: principles, practices and materials; bagging and labeling.

UNIT V

Seed storage: Seed drying and storage; drying methods-importance and factors affecting it, changes during storage, concepts and significance of moisture equilibrium, methods of maintaining safe seed moisture content. Methods to minimize the loss of seed vigour and viability; factors influencing storage losses. Storage methods and godown sanitation. Storage structures. Storage problems of recalcitrant seeds and their conservation.

Practicals

Operation and handling of mechanical drying equipments; effect of drying temperature and duration on seed germination and storability with particular reference to oil seeds; seed extraction methods; seed processing equipments; seed treating equipments; visit to seed processing plant and commercial controlled and uncontrolled Seed Stores; seed quality upgradation; measurement of processing efficiency; seed blending, bag closures; study of orthodox, intermediary and recalcitrant seeds; evaluating seed viability at different RH and temperature levels and packaging materials; prediction of storability by accelerated ageing controlled deterioration tests.

Suggested Readings

Agrawal, R.L. 1996. *Seed Technology*. Oxford Publishers

Barton, L.V. 1985. *Seed Preservation and Longevity*. International Books and Periodicals Supply Service, New Delhi.

Hall, C.W. 1966. *Drying of Farms Crops*. Lyall Book Depot.

Justice, O.L. and Bass, L.N. 1978. *Principles and Practices of Seed Storage*. Castle House Publ. Ltd.

Mathews, R.K., Welch, G.B., Delouche, J.C. and Dougherty, G.M. 1969. *Drying, Processing and Storage of Corn seed in Tropical and Subtropical Regions*. Proc. Am. Agric. Eng. St. Joseph, Mich. Paper No. 69-67.

Sahay, K.M. and Singh, K.K. 1991. *Unit Operations in Food Engineering*. Vikas Publ.

Virdi, S.S. and Gregg, B.G. 1970. *Principles of Seed Processing*. National Seed Corp., New Delhi.

SST 601 HYBRID SEED PRODUCTION

(2L + 2P) I

Objective

To provide a comprehensive knowledge and practical exposure to hybrid seed production in field crops and vegetables.

Theory

UNIT I

Heterosis: definition, expression and estimation of hybrid vigour; utilization of heterosis in agricultural, horticultural and other crop plants for crop improvement.

UNIT II

Pre requisites for hybrid seed production; mechanisms and management of pollination in autogamous and allogamous crops; genetic constitution of varieties, hybrids and basic principles in seed production.

UNIT III

Techniques of hybrid seed production - emasculation and crossing: use of self-incompatibility, modification of sex; types of male sterility and exploitation in hybrid development and its use in hybrid seed production; development and maintenance of A, B and R lines.

UNIT IV

Fertility restoration; use of chemical hybridizing agents, problems of non synchrony in flowering of parental lines and methods to overcome; planting ratios and population density in relation to hybrid seed yield; salient features of hybrid seed production of various crops viz., rice, sorghum, bajra, maize, sunflower, cotton and other major vegetables.

Practicals

Methods of hybrid seed production in major agricultural and horticultural crops; planting of rows / blocks of parental lines and manipulations for achieving flowering synchrony for production of hybrid seeds, maintenance of A, B and R lines and production of breeder seed; stable diagnostic characteristics of parental lines and their hybrids; genetic purity tests; determination of cost of hybrid seed production of various crops; visit to seed production plots etc.

(Pre-requisite: SST 502)

Suggested Readings

Basra, A.S. 2000. *Heterosis and Hybrid Seed Production in Agricultural Crops*. Food Product Press.

McDonald, M.B. and Copeland, L.O. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.

Singhal, N.C. 2003. *Hybrid Seed Production*. Kalyani Publishers.

SST 603 TESTING FOR GENUINENESS AND PURITY OF CULTIVARS

(2L +2P) II

Objective

To provide hands-on training on various field and laboratory methods of testing cultivar purity.

Theory

UNIT I

Objective of cultivar purity test, general principles and methods involved. Use and limitations of laboratory, green house and field plot methods in determination of genuineness of cultivars; a case study in hybrid cotton, reporting of results and inference.

UNIT II

Chemical-biochemical tests for species and cultivar purity: phenol test, seed and seedling tests, electrophoretic analysis of seed protein, isozymes etc, use of chromatography for analysis of secondary compounds etc.

UNIT III

DNA finger printing (RAPD, SSR, AFLP etc) and their use in varietal purity testing and registration of new varieties.

UNIT IV

Use of computer-based machine vision (MVT) for varietal identification and purity testing

Practicals

Chemical and biochemical tests for species and cultivar purity: phenol test, seed and seedling tests, electrophoretic analysis of seed protein and isozymes, DNA fingerprinting using PCR techniques, use of chromatography for analysis of secondary compounds.

Suggested Readings

Basra, A.S. (Ed.). 1995. *Seed Quality: Basic Mechanisms and Agricultural Implications*. Food Product Press.

ISTA. 2006. *Handbook of Variety Testing*. International Seed Testing Association, Switzerland

SST 604 DUS TESTING FOR PLANT VARIETY PROTECTION

(2L +1P) I

Objective

To provide a comprehensive understanding of DUS testing, its conduct and significance to PVP.

Theory

UNIT I

Genesis of plant variety protection (PVP); International Union for Protection of New Varieties of Plants (UPOV) and its functions; General agreements on Tariff and Trades (GATT) agreement in relation to protection of plant varieties; Protection of Plant Varieties and Farmers' Rights (PPV &FR) Act, 2001; PPV&FR rules, 2003.

UNIT II

Criteria for protection of new varieties of plants; principles and procedures of Distinctness, Uniformity and Stability (DUS) testing; test guidelines, planting material, duration, testing options, varieties of common knowledge, reference collection, grouping of varieties, types and categories of characters; technical questionnaire.

UNIT III

Assessment of DUS characters based on morphological, biochemical and molecular markers; statistical procedures; computer software for use in DUS testing; impact of PVP on growth of seed industry; practical exercise of DUS testing in rice, wheat, pearl- millet, maize, rose and cauliflower.

Practicals

Morphological description of plant parts and plant; character expression and states, recording observation and interpretation of data; chemical tests and markers applicable for DUS tests and case study of selected crops.

Suggested Readings

Chakrabarty, S.K., Prakash, S., Sharma, S.P. and Dadlani, M. 2007. *Testing of Distinctiveness, Uniformity and Stability for Plant Variety Protection*. IARI, New Delhi.

Joshi, A.K. and Singh, B.D. 2004. *Seed Science and Technology*. Kalyani.

The Protection of Plant Varieties and Farmers' Rights Act 2001. Bare Act with Short Notes 2006. Universal Law Publ.

Objective

To provide knowledge on the advances in various aspects of seed science & their application in seed technology.

Theory

UNIT I

Physiological and molecular aspects of seed development and control of germination and dormancy; gene expression during seed development; desiccation and stress tolerance and conservation; prediction of seed dormancy and longevity using mathematical models; structural changes in membranes of developing seeds during acquisition of desiccation tolerance; dehydration damage and repair in imbibed seeds, seed biotechnology; genetic analysis and QTL mapping of germination traits; seed ageing and ethylene production; recent accomplishments in seed enhancement research and application of nanotech.

UNIT II

Modern techniques for identification of varieties and hybrids; principles and procedures of electrophoresis, machine vision technique, DNA fingerprinting and other molecular techniques and their utilization; techniques for improving seed quality; proteomic analysis; seed priming, coating, pelleting and synthetic seeds; GM seeds and their detection, terminator technology (GURT).

UNIT III

Detection and identification of seed borne fungi, bacteria, viruses, nematodes and insect pests through advanced techniques like ELISA, PCR based techniques etc.

UNIT IV

Seed production of self incompatible and apomictic plant species; recent developments in seed laws, policies and seed certification system in India and its comparison with OECD seed certification schemes; IPR systems and PVP internationally.

Suggested Readings

Bench, A.L.R. and Sanchez, R.A. 2004. *Handbook of Seed Physiology*. Food Product Press.

Black, M. and Bewley JD. (Eds.). 2000. *Seed Technology and its Biological Basis*. Sheffield Academic Press.

Nicolas, G., Bradford, K.J., Come, D. and Pritchard, H.W. 2003. *The Biology of Seeds, Recent Research Advances*. CABI.

SST 608 / PP 608 PHYSIOLOGY OF SEEDS

(2L + 1P) III

Objective

To apprise students regarding seed germination, dormancy, physiological processes involved in regulation of seed development and physiological processes governing seed quality and its survival.

Theory

UNIT I

Introduction, importance of seeds, seed structure and function, chemical composition of seed, seed development and maturation – physiological and molecular aspects; hormonal regulation of seed development, desiccation tolerance and sensitivity in relation to seed longevity, LEA protein.

UNIT II

Physiological and biochemical changes during seed maturation assimilate movement to seeds, storage of carbohydrate, protein and fats in seeds and biosynthesis.

UNIT III

Seed germination, factors influencing, breakdown and mobilization of stored products, carbohydrate, fat, protein, respiration and pathways of interconversion, control process in the mobilization of food reserve, hormonal control of germination. Seed dormancy, different types, environmental influences, mechanism and control including phytochrome, methods of breaking seed dormancy.

UNIT IV

Factors influencing loss of seed viability during storage, physiological and biochemical changes associated with seed ageing,, theories of seed ageing, seed viability and its evaluation, seed storage, protection from water, temperature and contaminants, desiccation tolerance and sensitivity in relation to seed longevity.

UNIT V

Seed vigour, concept, importance, measurement; seed invigoration, methods, physiological and molecular basis of seed invigoration, effect of vigour on field emergence and yield, seed hardening.

Practicals

Chemical composition of seed, testing seed vigour and viability, breaking of seed dormancy, germination, seed invigoration and priming treatments, accelerated ageing treatments, seed imbibition and leakage, enzyme activities during germination, sink ability of ovules, seed respiration.

Suggested Readings

- Agrawal, P.K. and Dadlani, M. (Eds.). 1992. *Techniques in Seed Science and Technology*. South Asian Publ.
- Baskin, C.C. and Baskin, J.M. 1998. *Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination*. Academic Press.
- Basra, A.S. 2006. *Handbook of Seed Science and Technology*. Food Product Press.
- Bench, A.L.R. and Sanchez, R.A. 2004. *Handbook of Seed Physiology*. Food Product Press.
- Bewley, J.D. and Black, M. 1982. *Physiology and Biochemistry of Seeds in Relation to Germination*. Vols. I, II. Springer Verlag.
- Bewley, J.D. and Black, M. 1985. *Seed: Physiology of Seed Development and Germination*. Plenum Press.
- Copeland, L.O. and Mc Donald, M.B. 1995. *Principles of Seed Science and Technology*. 3rd Ed. Chapman & Hall.
- Khan, A.A. 1977. *Physiology and Biochemistry of Seed Dormancy and Germination*. North Holland Co.
- Kigel, J. and Galili, G. (Eds.). *Seed Development and Germination*. Marcel Dekker.
- Murray, D.R. 1984. *Seed Physiology*. Vols. I, II. Academic Press.
- Sadasivam, S. and Manickam A. 1996. *Biochemical Methods*. 2nd Ed. New Age.