Biologia Plantarum

Botanical Gazette

Botanical Review

Canadian Journal of Agricultural Research

Canadian Journal of Botany

Canadian Journal of Plant Science

Communications in Soil Science and Plant Analysis

Current Science

Environmental and Experimental Botany

Euphytica

Experimental Agriculture

Experimental Cell Biology

Functional Plant Biology

Indian Journal of Agriculture

Indian Journal of Experimental Biology

Indian Journal of Plant Physiology

International Journal of Botany

Japanese Journal of Crop Science

Journal of Agricultural and Scientific Research

Journal of Agricultural Science

Journal of Arid Environment

Journal of Experimental Botany

Journal of Plant Biology

Journal of Plant Nutrition

Nature

New Physiologist

Physiologia Plantarum

Physiology and Molecular Biology of Plants

Plant and Cell Physiology

Plant and Soils

Plant Cell, Tissue and Organ Culture

Plant Growth Regulator abstracts

Plant Physiology and Biochemistry

Plant Science

Plant Science (India)

Science Journal

Seed Science and Technology

Seed Science Research

Soil Science and Plant Nutrition

Soviet Plant Physiology

Trends in Plant Science

Tropical Agriculture

e-Resources

www.Bioone Online Journals The Arabiopsis Book.

www. Botany on line:

www.Ingenta Connect Physiologia Plantarum

www.new.phytologist.org.

www.plant physiol.org.

www.mpiz-Kolen.mpg.de.

www.Science Direct.

www.Scientia Agricolo.

www.wiley interscience.

Suggested Broad Topics for Master's and Doctoral Research

Environmental stress physiology- Salt, Drought, Heat, Freezing, and Heavy

Metal

Nodulation and nitrogen fixation in leguminous plants

Physiology of senescence and abscission in crop plants especially in cotton

Phytoremediation, especially with reference to salt and heavy metal stress

Ecophysiology of tree species to evaluate bio-drainage potential of plants under

waterlogged saline area

Growth and development of crop plants

Mineral nutrition in crop plant

Application of plant growth regulators to improve crop productivity

Photosynthesis, respiration and related processes for crop improvement

SEED SCIENCE AND TECHNOLOGY

Course Structure - at a glance

CODE	COURSE TITLE	CREDITS
SST 501*	FLORAL BIOLOGY, SEED DEVELOPMENT AND MATURATION	1+1
SST 502*	PRINCIPLES OF SEED PRODUCTION	2+0
SST 503*	SEED PRODUCTION IN FIELD CROPS	2+1
SST 504	SEED PRODUCTION IN VEGETABLES	2+1
SST 505	SEED PRODUCTION IN FLOWER, MEDICINAL, FRUIT AND PLANTATION CROPS	2+1
SST 506*	SEED LEGISLATION AND CERTIFICATION	2+1
SST 507*	SEED PROCESSING AND STORAGE	2+1
SST 508*	SEED QUALITY TESTING	2+1
SST 509@@@	SEED PHYSIOLOGY	2+1
SST 510	SEED PATHOLOGY	2+1
SST 511	SEED ENTOMOLOGY	2+1
SST 512	SEED PRODUCTION IN FORAGE, PASTURE AND GREEN MANURE CROPS	2+1
SST 513	SEED STORAGE AND DETERIORATION	1+1
SST 514	SEED MARKETING AND MANAGEMENT	1+1
SST 515	EMERGING TRENDS IN SEED QUALITY ENHANCEMNT	1+1
SST 516 @	GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE	2+1
SST 591	MASTER'S SEMINAR	1+0
SST 599	MASTER'S RESEARCH	20
SST 500 *	PROJECT WORK	0+4
SST 601**	HYBRID SEED PRODUCTION	1+1
SST 602@@	IN SITU AND EX SITU CONSERVATION OF GERMPLASM	2+1
SST 603	TESTING FOR GENUINENESS AND PURITY OF CULTIVARS	1+1
SST 604**	DUS TESTING FOR PLANT VARIETY PROTECTION	2+1
SST 605**	ADVANCES IN SEED SCIENCE RESEARCH	1+0
SST 691	DOCTORAL SEMINAR I	1+0
SST 692	DOCTORAL SEMINAR II	1+0
SST 699	DOCTORAL RESEARCH	45

*Compulsory for Master's programme;   ** Compulsory for Ph. D. programme

@ Cross listed with GP 516;   @@ Cross listed with GP 610 and SST 509 @@@ cross listed with PP 608

Minor Departments

Genetics and Plant Breeding

Plant Physiology

Plant Pathology

Entomology

Agricultural Engineering

Agricultural Economics

Agronomy

Biochemistry

Supporting Departments

Statistics and Mathematics

Plant Molecular Biology and Biotechnology

Non credit compulsory courses

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY INFORMATION SERVICES	0+1
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATION SKILLS	0+1
PGS 503 (e-course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-course)	DISASTER MANAGEMENT	1+0

SST 501   FLORAL BIOLOGY, SEED DEVELOPMENT AND MATURATION   1+1

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: microsporogenesis and megasporogenesis; 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. Physiological cum harvestable maturity with reference to germination and seed vigour, and fixing up of indices for seed harvesting; influence of weather, nutrition, soil moisture, plant protection chemicals, hormones and other cultural and management practices on seed development and maturation.

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, desiccation tolerance - role of LEA proteins and oligo saccharides.

Practical

Study of floral biology of monocots and dicots; microsporogenesis and megasporogenesis; 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; Study of physiological and harvestable maturity - morphological and chemical indices

Suggested Readings

Bhojwani SS & Bhatnagar SP. 1999. *The Embryology of Angiosperm.*Vikas Publ.

Black M, Bewley D & Halmer P. 2006. *The Encyclopedia of Seeds: Science, Technology and Uses.* CABI.

Chhabra AK. 2006. *Practical Manual of Floral Biology of Crop Plants*. Deptt. of Plant Breeding, CCS HAU, Hisar.

Copeland LO & McDonald MB. 2001. *Principles of Seed Science and Technology*. 4th Ed. Chapman & Hall.

Frankel R & Galun E. 1977. *Pollination Mechanisms, Reproduction and Plant Breeding*. Springer Verlag.

SST 502	PRINCIPLES OF SEED PRODUCTION	2+0

Objective

To introduce the basic principles of quality seed production.

Theory

UNIT I

Introduction : Seed as basic input in agriculture; seed development in cultivated plants; seed quality concept and importance of genetic purity in seed production; types of cultivars, their maintenance and factors responsible for deterioration; seed production in self and cross pollinated crops.

UNIT II

Mode of pollination and reproduction in crop plants and their modification in relation to hybrid seed production. Principles of hybrid seed production, isolation distance, synchronization of flowering, roguing etc. male sterility and incompatibility system in hybrid seed production, role of pollinators and their management.

UNIT III

Seed multiplication ratios, seed replacement rate, demand and supply; suitable areas of seed production and storage, agronomy of seed production – agro climatic requirements and their influence on quality seed production; generation system of seed multiplication; maintenance of Nucleus seed, production of Breeder, Foundation and Certified seed– criteria involved; life span of a variety and causes for its deterioration; certification standards for self and cross pollinated and vegetatively propagated crops.

UNIT IV

Hybrid Seed - Methods of development of hybrids; use of male sterility and self-incompatibility and CHA in hybrid seed production; one, two and three line system; maintenance of parental lines of hybrids; planning and management of hybrid seed production technology of major field crops and vegetables.

UNIT V

Planning of seed production for different classes of seeds for self and cross pollinated crops, Seed quality control system and organization, seed village concept - Participatory seed production.; Seed production agencies, seed industry and custom seed production in India.

Suggested Readings

Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.

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

Desai BB. 2004. *Seeds Handbook*. Marcel Dekker.

Kelly AF. 1988. *Seed Production of Agricultural Crops*. Longman.

McDonald MB Jr & Copeland LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.

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

Poehlman JM & Sleper DA. 2006. *Breeding Field Crops*. Blackwell.

Singh BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani.

Singhal NC. 2003. *Hybrid Seed Production in Field Crops*. Kalyani.

Thompson JR. 1979. *An Introduction to Seed Technology*. Leonard Hill.

Tunwar NS & Singh SV. 1985. *Handbook of Cultivars*. CSCB, GOI.

SST 503	SEED PRODUCTION IN FIELD CROPS	2+1

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, soybean, cowpea 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, Niger 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, zinger, turmeric etc.

Practical

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, Working out cost – benefit ratio for different crops; and visits to seed production plots etc.

Suggested Readings

Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.

Kelly AF. 1988. *Seed Production of Agricultural Crops*. John Wiley.

McDonald MB Jr & Copeland LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.

Singhal NC. 2003. *Hybrid Seed Production in Field Crops*. Kalyani.

| SST 504 | SEED PRODUCTION IN VEGETABLES | 2+1 |

Objective

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

Theory

UNIT I

Introduction; modes of propagation in vegetables. Seed morphology and development in vegetable seeds. Floral biology of these plant species; classification of vegetable crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops.

UNIT II

Classification based on growth cycle and pollination behavior; methods of seed production; comparison between different methods e.g. seed-to-seed vs. root-to-seed method in radish; seed multiplication ratios in vegetables; pollination mechanisms; sex types, ratios and expression and modification of flowering pattern in cucurbits; nursery raising and transplanting stage.

UNIT III

Seed production technology of vegetables viz. solanaceous, cucurbitaceous, leguminous, malvaceous, cole crops, leafy vegetables, root, tuber and bulb crops and spices; harvesting/ picking stage and seed extraction in fruit vegetables; clonal propagation and multiplication in tuber crops e.g. Potato, sweet potato, colocasia, tapioca; seed-plot technique in potato tuber seed production; hybrid seed production technology of vegetable crops, TPS (true potato seed) and its production technique; hybrids in vegetables; maintenance of parental lines; use of male sterility and self incompatibility in hybrid seed production, environmental factors related to flowering/bolting in vegetable crops.

SST 505 **SEED PRODUCTION IN FLOWER, MEDICINAL, FRUIT AND PLANTATION CROPS** 2+1

Objective

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

Theory

UNIT I

Introduction: modes of propagation in fruits, flower and plantation crops. Floral biology of these plant species; classification of medicinal and horticultural crops based on pollination

UNIT IV

Share of vegetable seeds in seed industry; importance and present status of vegetable seed industry; intellectual property rights and its implications, impact of PVP on growth of seed industry.

Practical

Selection of suitable areas/locations for high quality seed/planting material production; study of floral biology of vegetables, determination of planting ratios for hybrid seed production of vegetables; use and maintenance of monoecious line in hybrid seed production of cucumber; exercises on emasculation and pollination; seed extraction methods and their effect on quality of vegetables; seed production technology of varieties and hybrids in vegetables.

Suggested Readings

Agrawal RL. 1997. *Seed Technology.* 2nd Ed. Oxford & IBH.

Bose TK, Mitra SK and Sadhur NK 1990. Propagation of tropical and sub tropical horticultural crops. Naya Prakash, Calcutta.

Desai BB, Katecha, PM & Salunke DK. 1997. *Seed Hand Book: Biology, Production, Processing and Storage.* Marcel Dekker.

Desai BB. 2004. *Seeds Handbook.* Marcel Dekker.

George RAT. 1980. *Vegetable Seed Technology. A Technical Guide to Vegetable Seed Production, Processing, Storage and Quality Control.* FAO, Rome.

Hartman HT & Kester DE. 2000. *Plant Propagation: Principles and Practices.* Prentice Hall.

Kelly AF & George RAT. (Eds.) 1998. *Encyclopedia of Seed Production of World Crops.* John Wiley & Sons.

McDonald MB Jr & Copeland LO. 1997. *Seed Production of Crops: Principles and Practices.* Chapman & Hall.

Salunkhe DK, Desai BB & Bhat RN. 1987. *Vegetable and Flower Seed Production.* Agricole Publ. Academy.

Singh SP. 2001. *Seed Production of Commercial Vegetables.* Agrotech.

Singhal NC. 2003. *Hybrid Seed Production in Field Crops.* Kalyani.

Vanangamudi, K et al.,2006 Advances in seed science and Technology : (Vol II) Quality seed production in vegetable crops Agrobios (India), Jodhpur.

and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops.

UNIT II

Flowers and Medicinal Plants; classification based on growth cycle, reproduction and pollination behavior; nursery requirement, planning and management; technology for quality seed production in important flower species i.e. marigolds, petunias, dahlia, roses, gladiolus, tulips, chrysanthemum etc; development of hybrids and their seed production technology. Seed production technology of annual medicinal plants viz. isabgol, ashawagandha etc.

UNIT III

Fruit and Plantation Crops: role of seed in perennial plant species; classification based on reproduction and pollination behavior; polyembryony and its significance; nursery requirement, planning and management; clonal propagation and multiplication in tropical, sub-tropical and temperate fruits and plantation crops; seed orchards; seed collection, extraction and processing.

UNIT IV

IPR issues with special reference to floral and plantation crops.

Practical

Selection of suitable areas/locations for high quality seed/planting material production; study of floral biology of flowers, Fruits, Medicinal and plantation crops; Determination of planting ratios for hybrid seed production in flowers; Exercises on emasculation and pollination; Seed extraction methods and their effect on quality of fruit; Seed production technology of varieties and hybrids; Seed collection and extraction in fruit and plantation crops.

Suggested Readings

Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.

Desai BB, Katecha, PM & Salunke DK.1997. *Seed Hand Book: Biology Production, Processing and Storage*. Marcel Dekker.

Desai BB. 2004. *Seeds Handbook*. Marcel Dekker.

Doijode SD. 2001. *Seed Storage of Horticultural Crops*. CBS.

George RAT. 1980. *Vegetable Seed Technology. A Technical Guide to Vegetable Seed Production, Processing, Storage and Quality Control*. FAO, Rome.

Hartman HT & Kester DE. 2000. *Plant Propagation: Principles andPractices*. Prentice Hall.

ICAR. *Hand Book of Horticulture*. ICAR Publ.

Kelly AF & George RAT. (Eds.).1998. *Encyclopedia of Seed Production of World Crops*. John Wiley & Sons.

McDonald MB Jr & Copeland LO. 1997. *Seed Production of Crops:Principles and Practices*.

Chapman & Hall. Salunkhe

DK, Desai BB & Bhat RN. 1987. *Vegetable and Flower SeedProduction*. Agricole Publ. Academy.

Singh SP. 2001. *Seed Production of Commercial Vegetables*.Agrotech.

Singhal NC. 2003. *Hybrid Seed Production in Field Crops*. Kalyani.

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); Packaging commodities order (1955); The standards of weights and measurements Act (1976); 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.

Practical

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 RL. 1997. *Seed Technology.* Oxford & IBH.

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

Nema NP. 1986. *Principles of Seed Certification and Testing.* Allied Publs.

Ramamoorthy K, Sivasubramaniam K and Th.A. Kannan 2006. *Seed Legislation in India.* Agrobios, Jodhpur.

Tunwar NS & Singh SN. 1988. *Indian Minimum Seed Certification Standards.* CSCB, Ministry of Agriculture, New Delhi.

SST 507   **SEED PROCESSING AND STORAGE**   **2+1**

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- Designing of seed storage structures, Storage problems of recalcitrant seeds and their conservation.

Practical

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 RL. 1996. *Seed Technology*. Oxford Publ.

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

Hall CW. 1966. *Drying of Farms Crops*. Lyall Book Depot.

Justice OL & Bass LN. 1978. *Principles and Practices of Seed Storage*. Castle House Publ. Ltd.

Mathews RK, Welch GB, Delouche JC & Dougherty GM. 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 KM & Singh K.K. 1991. Unit Operations in Food Engineering. Vikas Publ.

Virdi SS & Gregg BG. 1970. *Principles of Seed Processing*. National Seed Corp., New Delhi.

SST 508   **SEED QUALITY TESTING**   **2+1**

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. National and international organizations in seed testing; ISTA and its role in seed testing.

UNIT II

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 III

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 IV

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 V

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.

UNIT VI

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 VII

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 VIII

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. Important storage pests, their identification, monitoring and detection.

UNIT VIII

Testing of pelleted and coated seeds; Testing of GM seeds and trait purity, load of detection (LOD).

UNIT X

Preparation and dispatch of seed testing reports; storage of guard samples; application and use of seed standards and tolerances.

Practical

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);

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Seed dormancy breaking methods requirements for conducting germination test, Specifications and proper use of different substrata for germination; Seed germination testing in different agri-horticultural 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; Pest damage evaluation; Testing coated/pelleted seeds.

Suggested Readings

Agarwal RL. 1997. *Seed Technology*. Oxford & IBH.

Agrawal PK & Dadlani M.1992. *Techniques in Seed Science and Technology*. 2nd Ed. South Asian Publ.

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

Copland LO & McDonald MB. 1996. *Principles of Seed Science and Technology*. Kluwer. ISTA 2006. *Seed Testing Manual*. ISTA, Switzerland.

Karuna V. 2007 *Seed Health Testing* Kalyani.

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

Tunwar NS & Singh SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

SST 509	SEED PHYSIOLOGY	2+1

Objective

To provide an insight into physiological processes governing seed quality and its survival.

Theory

UNIT I

Physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal regulation of seed development.

UNIT II

Seed germination; factors affecting germination-role of embryonic axis; growth hormones and enzyme activities, effect of age, size and position of seed on germination. Physiological processes during seed germination; seed respiration, breakdown of stored reserves in seeds, mobilization and interconversion pathways. Seed dormancy- types, significance, mechanism, endogenous and exogenous factors regulating dormancy, role of phytochrome and PGR, genetic control of dormancy.

UNIT III

Seed viability and longevity, pre and post-harvest factors affecting seed viability; seed ageing; physiology of seed deterioration ; lipid peroxidation and other viability theories; means to prolong seed viability; mechanism of desiccation sensitivity and recalcitrance with respect to seed longevity.

UNIT IV

Seed vigour and its concept, vigour test methods, factors affecting seed vigour, physiological basis of seed vigour in relation to crop performance and yield. Seed invigoration and its physiological and molecular control.

Practical

Proximate analysis of chemical composition of seed; Methods of testing viability; kinetics of seed imbibition and solute leakage; seed germination and dormancy breaking methods; seed invigoration and priming treatments; accelerated ageing and controlled deterioration tests; enzymatic activities and respiration during germination and effect of accelerated ageing; vigour testing methods etc.

Suggested Readings

Agrawal PK & Dadlani M. (Eds.). 1992. *Techniques in Seed Science and Technology*. South Asian Publ.

Baskin CC & Baskin JM. 1998. *Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination*. Academic Press.

Basra AS. 2006. *Handbook of Seed Science and Technology*. Food Product Press.

Bench ALR & Sanchez RA. 2004. *Handbook of Seed Physiology*. Food Product Press.

Bewley JD & Black M. 1982. *Physiology and Biochemistry of Seeds in Relation to germination*. Vols. I, II. Springer Verlag.

Bewley JD & Black M. 1985. *Seed: Physiology of Seed Development and Germination*. Plenum Press.

Copeland LO & Mc Donald MB. 1995. *Principles of Seed Science and Technology*. 3rd Ed. Chapman & Hall.

Khan AA. 1977. *Physiology and Biochemistry of Seed Dormancy and Germination*. North Holland Co.

Kigel J & Galili G. (Eds.). *Seed Development and Germination*.

Marcel Dekker. Murray DR. 1984. *Seed Physiology*. Vols. I, II. Academic Press.

Sadasivam S & Manickam A. 1996. *Biochemical Methods*. 2nd Ed. New Age.

SST 510   SEED PATHOLOGY   2+1

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 seed pathology in seed industry and plant quarantine; terminology, important seed transmitted pathogens; seed microbes and their mode of action, detection techniques and identification of common seed borne pathogens.

UNIT II

Morphology and anatomy of typical monocotyledonous and dicotyledonous seeds; mode and mechanism of transmission of seed borne pathogens and microorganisms. Rate of transmission of major plant pathogens, microorganisms in relation to seed certification and tolerance limit; type of losses caused by seed-borne diseases.

UNIT III

Role of microorganisms in seed quality deterioration; management of seedborne plant pathogens/diseases and procedure for healthy seed production; different seed health testing methods for detecting microorganisms; Special detection methods of seed pathogen- histo pathological studies of seed borne pathogens; treatments to control seed borne diseases.

UNIT IV

Pest Risk Analysis (PRA) and disease free seed production, Sanitary & Phytosanitory (SPS) requirements in seed trade, International regulation (ISHI) in respect of seed health standards. Objectionable seed borne diseases.

Practical

Different methods of examination of seeds to assess seed-borne microorganisms and to quantify infection percentage, Detection of seed borne fungi, Bacteria and viruses, Identification of storage fungi, Control of seed borne diseases, Seed treatment methods.

Suggested Readings

Agarwal VK & Sinclair JB. 1997. *Principles of Seed Pathology.* Boca Raton.

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

Mathur SB and Kn Mortensen 1997. Seed health testing in the production of Quality seeds. ISTA. Zurich.

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

SST 511	SEED ENTOMOLOGY	2+1

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.

Practical

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 handing 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 NA & Girish GK. 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 JA & Aleock AW. 1954. *Storage of Cereal Grain & their Products*. American Assoc. Cereal Chemists, St. Pauls, Minn.

Cottong RT. 1963. *Insect Pests of Stored Grain and Grain Products*. Burgess Publ. Co., Minneopolis, Minn., USA.

Monro 1969. *Manual of Fumigation for Insect Control*. FAO Rome Agril. Studies No. 79.

Subramanyam B & Hagstrum DW. 1995. *Interrelated Management of Insects in Stored Products*. Marcel Dekker.

SST 512   **SEED PRODUCTION IN FORAGE, PASTURE AND GREEN MANURE CROPS**   **2+1**

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 these crops.

Practical

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

Farity DT & Hampton JC. 1997. *Forage Seed Production*. Vol. I. *Temperate species*. CABI.

Froma J. 1997. *Temperate Forage Legumes*. CABI.

Gutterridge RG. 1997. *Forage Tree Legumes in Tropical Agriculture*. CABI.

Quality Declared Seed System. 2007. FAO Plant Production and Protection Publication No.185: FAO, Rome.

SST 513　　　　　**SEED STORAGE AND DETERIORATION**　　　　**1+1**

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; Techniques of handling and storage of recalcitrant 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.

Practical

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 LV. 1961. *Seed Preservation and Longevity*. Burgess Publ.

Basra AS. (Ed.). 1995. *Seed Quality: Basic Mechanisms and Agricultural Implications*. Food Products Press.

Basra AS. 2006. *Handbook of Seed Science and Technology*. Food Product Press.

Desai BB. 2007. *Seed Handbook: Biology, Production, Processing andStorage*. Marcel Dekker.

Doijode SD. 2001. *Seed Storage of Horticultural Crops*. CBS.

Justice OL & Bass LN. 1978. *Principles and Practices of Seed Storage*. Castle House Publ.

Kharb RPS & Kharb P. 1977. Biochemical and Cytogenetical Changes During Storage. In: *Seed Technology* (Eds. BS Dahiya & KN Rai): pp. 160-168.

McDonald MB & Roos EE. (Eds.). 1986. *Physiology of Seed Deterioration*. Paper No. 11, Crop Science Society of America, USA.

Roberts EH. 1972. *Viability of Seeds*. Chapman & Hall.

SST 514   SEED MARKETING AND MANAGEMENT   1+1

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.

Practical

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 RL & Uhl JN. 1980. *Marketing of Agricultural Products*. MacMillan.

Kundu KK & Suhag KS. 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 TRENDS IN SEED QUALITY ENHANCEMENT   1+1

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.

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UNIT II

Seed invigoration treatments and seed hardening; Seed priming: physiological and biochemical basis, types of priming technology, biochemical and molecular changes associated, pregermination, 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, cryopreservation, storage of artificial seeds, desiccation tolerance, use of botanicals in improving seed quality etc.

Practical

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 AS. (Ed.). 1995. *Seed Quality: Basic Mechanisms and Agricultural Implications.* Food Product Press, NY.

Basra AS. 2006. *Handbook of Seed Science and Technology.* Food Product. Press, NY

Bench ALR & Sanchez RA. 2004. *Handbook of Seed Physiology.* Food Product Press, NY/ London.

Copland LO & Mc Donald MB. 2004. *Seed Science and Technology.* Kluwer Acad.

Kalloo G, Jain SK, Vari AK & Srivastava U. 2006. *Seed: A Global Perspective.* Associated Publishing Company, New Delhi.

Vanangamudi, K et al., 2006 *Advances in seed science and Technology* : (Vol I) Recent Trends in Seed Technology and Management. Agrobios (India), Jodhpur

SST 516   GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE   2+1

Objective

To provide information about collection, germplasm exchange, quarantine, maintenance and use of plant genetic resources including genetically modified plants.

Theory

UNIT I

History and importance of germplasm exploration; Distribution and extent of prevalent genetic diversity; Phyto-geographical regions/ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora.

UNIT II

Concept of population and gene pool; Variations in population and their classification; Gene frequencies in populations, rare and common alleles; Gene pool sampling in self

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and cross pollinated and vegetatively propagated species; Non-selective, random and selective sampling strategies; Strategies and logistics of plant exploration and collection; Coarse and fine grid surveys; Practical problems in plant exploration; Use of *in vitro* methods in germplasm collection.

UNIT III

Ethnobotanical aspects of PGR; Crop botany, farming systems, collecting wild relatives of crop plants; Collection and preservation of specimens; Importance and use of herbaria and preparation of herbarium specimens.

UNIT IV

Post-exploration handling of germplasm collections; Present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum, sesame, *Brassica*, okra, eggplant, cotton, mango etc; approaches for collection including indigenous knowledge.

UNIT V

History, principles, objectives and importance of plant introduction; Prerequisites, conventions, national and international legislations and policies on germplasm collection and exchange; Documentation and information management; Plant quarantine- introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up in India; Pest risk analysis, pest and pathogen information database; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses, phytoplasma etc.).

UNIT VI

Detection and identification of pests including use of recent techniques like ELISA, PCR etc., Symptoms of pest damage, salvaging techniques for infested/infected germplasm, post-entry quarantine operation, seed treatment and other prophylactic treatments and facilities; Domestic quarantine; seed certification; International linkages in plant quarantine; weaknesses and future thrust.

UNIT VII

Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for biosafety.

Practical

Plant exploration and collection; Techniques of coarse and fine grid surveys; Identification of wild relatives of crop plants- Example of collection, Cataloguing and preservation of specimens; Sampling techniques of plant materials; Visiting ports, Airports to study the quarantine regulations; Techniques for the detection of insects, Mites, Nematodes, Bacteria, Weeds, Pathogens and viruses on seed and planting materials and salvaging; Use of visual, Qualitative, Quantitative, Microscopic, Molecular and plant growth related techniques (controlled green houses/growth chambers, etc); Detection of GMOs and GEPs; Study of post-entry quarantine operation, Seed treatment and other prophylactic treatments.

Suggested Readings

Briggs D. 1997. *Plant Variation and Evolution*. Science Publ. Cronquist AJ. 1981. *An Integrated System of Classification of Flowering Plants*. Columbia Univ. Press.

Dhillon BS, Varaprasad KS, Kalyani S, Singh M, Archak S, Srivastava U & Sharma GD. 2001.

Germplasm Conservation A Compendium of Achievements. NBPGR, New Delhi.

di Castri F & Younes T. 1996. *Biodiversity Science and Development: Towards New Partnership.* CABI & International Union for Biol. Sci. France.

Gurcharan Singh. 2004. *Plant Systematics: An Integrated Approach.* Science Publ.

Lawrence GMH. (Ed.). 1951. *Taxonomy of Vascular Plants.* London.

Paroda RS & Arora RK. 1991. *Plant Genetic Resources Conservation and Management Concepts and Approaches.* IPGRI Regional office for South and South Asia, New Delhi.

Pearson LC. 1995. *The Diversity and Evolution of Plants.* CRC Press.

Singh BP. 1993. *Principles and Procedures of Exchange of Plant Genetic Resources Conservation and Management.* Indo-US PGR Project Management.

Sivarajan VV. 1991. *Introduction of Principles of Plant Taxonomy.* Science Publ.

Stace CA. Plant Taxonomy and Biosystematics 2nd Ed. Cambridge Univ.Press.

Takhrajan A. 1997. *Diversity and Classification of Flowering Plants.* Columbia Univ. press.

Wiersema JH. 1999. *World Economic Plants: A Standard Reference.* Blanca Leon.

SST 601   HYBRID SEED PRODUCTION   1+1

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, pigeon pea and other major vegetables.

Practical

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.

Suggested Readings

Basra AS. 2000. *Heterosis and Hybrid Seed Production in Agricultural Crops.* Food Product Press.

McDonald MB & Copeland LO. 1997. *Seed Production: Principles and Practices.* Chapman & Hall.

Singhal NC. 2003. *Hybrid Seed Production.* Kalyani Publishers.

SST 602   *IN SITU* **AND** *EX SITU* **CONSERVATION OF GERMPLASM**   **2+1**

Objective

To impart knowledge on the methods of germplasm conservation.

Theory

UNIT I

Concept of natural reserves and natural gene banks, *In situ* conservation of wild species in nature reserves: *in situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation; *in situ* conservation of agro-biodiversity on-farm; scientific basis of *in situ* conservation on-farm, building on-farm conservation initiatives, implementation of on-farm conservation, management of *in situ* conserved genetic diversity on-farm, enhancing benefits for farmers from local crop diversity.

UNIT II

Ex situ conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, *perma-frost* conservation, guidelines for sending seeds to network of active/ working collections, orthodox, recalcitrant seeds- differences in handling, clonal repositories, genetic stability under long term storage condition.

UNIT III

In vitro storage, maintenance of *in vitro* culture under different conditions, *in vitro* bank maintenance for temperate and tropical fruit crop species, spices, tubers, bulbous crops, medicinal and endangered plant species, conservation of embryos and ovules, cell/ suspension cultures, protoplast and callus cultures, pollen culture, micro propagation techniques, problems, prospects of *in vitro* gene bank.

UNIT IV

Cryopreservation- procedure for handling seeds of orthodox and recalcitrants- cryoprotectants, dessication, rapid freezing, slow freezing, vitrification techniques, encapsulation/dehydration techniques, national facilities, achievements, application of

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cryopreservation in agriculture, horticulture and forestry crops. Problems and prospects; challenges ahead.

Practical

In situ conservation of wild species –case studies at national and international levels- *ex situ* techniques for active and long-term conservation of collections- Preparation and handling of materials, Packaging, Documentation; Design of cold storage modules- Conservation protocols for recalcitrant and orthodox seeds; Cytological studies for assessing genetic stability, *in vitro* cultures- embryo, Cell/suspension cultures, Pollen cultures, Study of cryotank facility and vitrification techniques, Visit to NBPGR/NBAGR -study using fruit crops and other horticultural crops.

Suggested Readings

Ellis RH & Roberts EH & White Head J. 1980. *A New More Economic and Accurate Approach to Monitor the Viability of Accessions During Storage in Seed Banks*. FAO / IBPGR Pl. Genet. Resources News 41-3-18.

Frankel OH & Hawkes JG. 1975. *Crop Genetic Resources for Today andTomorrow*. Cambridge University Press, Cambridge.

Simmonds, N.W. 1979. *Principles of Crop Improvement* Longman.

Westwood MN. 1986. *Operation Manual for National Clonal Germplasm Repository Processed Report*. USDA-ARS and Orgon State Univ. Oregon, USA.

Withers LA. 1980. *Tissue Culture Storage for Genetic Conservation*. IBPGR Tech. Rep. IBPGR, Rome, Italy.

SST 603   TESTING FOR GENUINENESS AND PURITY OF CULTIVARS   1+1

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, peroxidase test, auxin 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.

Practical

Study of morphological characteristic features for varietal identification in major field and vegetable crops, 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. Visit to GOT farms and DNA Finger Printing Labs.

Suggested Readings

Basra AS. (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	2+1

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.

Practical

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 SK, Prakash S, Sharma SP & Dadlani M. 2007. *Testing Of Distinctiveness, Uniformity And Stability For Plant Variety Protection.* IARI, New Delhi.

Joshi AK & Singh BD. 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.

SST 605

ADVANCES IN SEED SCIENCE RESEARCH 1+0

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 nanotechnology.

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 ALR & Sanchez RA. 2004. *Handbook of Seed Physiology*. Food Product Press.

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

Nicolas G, Bradford KJ, Come D & Pritchard HW. 2003. *The Biology of Seeds, Recent Research Advances*. CABI.

List of Journals

Crop Science

Hort. Science

Acta Hoticulturae

Indian Journal of Agricultural Science.

Journal of Seed Technology

Plant Varieties and Seeds

Seed Abstracts

Seed Research

Seed Science & Technology

Seed Science Research

New Seed Journal

Journal of Seed Production

ISST News Bulletin

e-Resources

Ag Biotech Reporter www.bioreporter.com

Agricultural Research Magazine *www.ars.usda.gov/is/AR/*

American Seed Trade Association www.amseed.com

Association of Official Seed Certifying Agencies www.AOSCA.org

Association of Official Seed Analysts www.aosaseed.com

Commercial Seed Analysts Association of Canada www.seedanalysts.com

Front Range Seed Analysts www.frsa.org

International Seed Federation www.wordseed.org

International Seed Testing Association www.seedtest.org

International Society for Seed Science www.css.comell.edu/ISSS/isss.htm

International Society of Seed Technologists www.isstech.org

The Seed Biology web page at Cornell University
www.css.comell.edu/seedbio/seedbio.html

Seed Biology at the Laboratory of Plant Physiology at the Wageningen University
www.wau.nl/uk/organisation

The Ohio State Seed Biology webpage www.css.ohio-state.edu/%7Eseebio/

The Seed Biotechnology Center University of California http://sbc.ucdavis.edul

Seed Viability and Storage Research Unit www.arsgrain.
gov/ars/NoPlains/FtCollins/preservation.htm

Seed World www.seedworld.com

Seed Quest www.seedquest.com

Seed Today www.seedtoday.com/info/ST sites.html

The South African National Seed Organization www.sansor.org/index.htm

Society of Commercial Seed Technologists www.seedtechnology.net

Wageningen Seed Centre www.seedcentre.nl

Suggested Broad Areas for Master's and Doctoral Research

Isolation distance requirements in view of GM varieties

Review of seed certification standards

GOT –seasonal requirements

Genetic purity vis-a-vis trait purity

Enhancement of pollen viability, stigma receptivity and seed setting

Reduction of processing losses

Alternate areas / protected cultivation methods for hybrid seed production

Standardising processing needs in high value crops and forage grasses

Protein and oil content in GM cotton seed and its effect on longevity

Optimisation of hybrid seed production technology in field crops, vegetables and flowers

Pollen collection methods and viability testing

Management of seed borne diseases with biocontrol agents

Seed enhancement for unfavorable conditions

Identification of markers for hybrid confirmation and genetic purity testing

GM seed testing

Seed testing protocols and seed standards for forage crops, medicinal species and spices

Molecular control of seed viability, vigour and invigoration

Standardisation of priming, coating and pelleting technologies

Development of technologies for maintenance of parental lines of SI and MS based hybrids

Any other location specific problems

SOIL SCIENCE
Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
SOILS 501*	SOIL PHYSICS	2+1
SOILS 502*	SOIL FERTILITY AND FERTILIZER USE	3+1
SOILS 503*	SOIL CHEMISTRY	2+1
SOILS 504*	SOIL MINERALOGY, GENESIS, CLASSIFICATION AND SURVEY	2+1
SOILS 505	SOIL EROSION AND CONSERVATION	2+1
SOILS 506*	SOIL BIOLOGY AND BIOCHEMISTRY	2+1
SOILS 507	GEOMORPHOLOGY AND GEOCHEMISTRY	2+0
SOILS 508	RADIO ISOTOPES IN SOIL AND PLANT STUDIES	1+1
SOILS 509	SOIL, WATER AND AIR POLLUTION	2+1
SOILS 510	REMOTE SENSING AND GIS TECHNIQUES FOR SOIL, WATER AND CROP STUDIES	2+1
SOILS 511	ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS	0+2
SOILS 512	SYSTEM APPROACHES IN SOIL AND CROP STUDIES	2+1
SOILS 513	MANAGEMENT OF PROBLEM SOILS AND WATERS	2+1
SOILS 514	FERTILIZER TECHNOLOGY	1+0
SOILS 591	MASTER'S SEMINAR	1+0
SOILS 599	MASTER'S RESEARCH	20
SOILS 515	LAND DEGRADATION AND RESTORATION	1+0
SOILS 601	ADVANCES IN SOIL PHYSICS	2+0
SOILS 602	ADVANCES IN SOIL FERTILITY	2+0
SOILS 603	PHYSICAL CHEMISTRY OF SOILS	2+0
SOILS 604	SOIL GENESIS AND MICROPEDOLOGY	2+0
SOILS 605	BIOCHEMISTRY OF SOIL ORGANIC MATTER	2+0
SOILS 606	LAND USE PLANNING AND WATERSHED MANAGEMENT	2+0
SOILS 691	DOCTORAL SEMINAR - I	1+0
SOILS 692	DOCTORAL SEMINAR - II	20
SOILS 699	DOCTORAL RESEARCH	45

* Compulsory for Master's Programme.

Minor Departments

Agronomy

Plant Physiology

Microbiology

Supporting Departments

Statistics & Mathematics

Biochemistry

Microbiology

Environmental Science & Technology

Horticulture

Non credit compulsory courses

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATION SKILLS	0+1
PGS 503 (e-course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-course)	DISASTER MANAGEMENT	1+0

Objective

To impart basic knowledge about soil physical properties and processes in relation to plant growth.

Theory

UNIT I

Scope of soil physics and its relation with other branches of soil science; soil as a three phase system.

UNIT II

Soil texture, textural classes, mechanical analysis, specific surface.

UNIT III

Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts.

UNIT IV

Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting - mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

UNIT V

Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

UNIT VI

Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

UNIT VII

Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

UNIT IX

Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

UNIT X

Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

Mechanical analysis by pipette and international methods, Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum blocks, Determination

of soil-moisture characteristics curve and computation of pore-size distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields

Suggested Readings

Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.

Ghildyal BP & Tripathi RP. 2001. *Soil Physics*. New Age International.

Hanks JR & Ashcroft GL. 1980. *Applied Soil Physics*. Springer Verlag.

Hillel D. 1972. *Optimizing the Soil Physical Environment toward Greater Crop Yields*. Academic Press.

Hillel D. 1980. *Applications of Soil Physics*. Academic Press.

Hillel D. 1980. *Fundamentals of Soil Physics*. Academic Press.

Hillel D. 1998. *Environmental Soil Physics*. Academic Press.

Hillel D. 2003. *Introduction to Environmental Soil Physics*. Academic Press.

Indian Society of Soil Science. 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley- Interscience.

Kohnke H. 1968. *Soil Physics*. McGraw Hill.

Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.

Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

Saha AK. 2004. *Text Book of Soil Physics*. Kalyani.

SOILS 502   SOIL FERTILITY AND FERTILIZER USE   3+1

Objective

To impart knowledge about soil fertility and its control, and to understand the role of fertilizers and manures in supplying nutrients to plants so as to achieve high fertilizer use efficiency.

Theory

UNIT I

Soil fertility and soil productivity; Nutrient sources – Fertilizers and manures; essential plant nutrients - functions and deficiency symptoms.

UNIT II

Soil and fertilizer nitrogen – Sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation - types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

UNIT III

Soil and fertilizer phosphorus - Forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions.

UNIT IV

Potassium - Forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

UNIT V

Sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium—factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

UNIT VI

Micronutrients – Critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

UNIT VII

Common soil test methods for fertilizer recommendations; Quantity– Intensity relationships; soil test crop response correlations and response functions.

UNIT VIII

Fertilizer use efficiency; Blanket fertilizer recommendations – Usefulness and limitations; Site-specific nutrient management; Plant need based nutrient management; integrated nutrient management.

UNIT IX

Soil fertility evaluation - Biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical

Principles of colorimetry, Flame-photometry and atomic absorption spectroscopy, Chemical analysis of soil for total and available nutrients, Analysis of plants for essential elements

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.

Kabata-Pendias A & Pendias H. 1992. *Trace Elements in Soils and Plants*. CRC Press.

Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.

Leigh JG. 2002. *Nitrogen Fixation at the Millennium*. Elsevier.

Mengel K & Kirkby EA. 1982. *Principles of Plant Nutrition*. International Potash Institute, Switzerland.

Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

Pierzinsky GM, Sims TJ & Vance JF. 2002. *Soils and Environmental Quality*. 2nd Ed. CRC Press.

Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.

Tisdale SL, Nelson SL, Beatcn JD & Havlin JL. 1999. *Soil Fertility and Fertilizers*. 5th Ed. Prentice Hall of India.

Troeh FR & Thompson LM. 2005. *Soils and Soil Fertility*. Blackwell.

SOILS 503   SOIL CHEMISTRY   2+1

Objective

To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils in relation to using soils as a medium for plant growth.

Theory

UNIT I

Chemical (elemental) composition of the earth's crust and soils.

UNIT II

Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics.

UNIT III

Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions.

UNIT IV

Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, statistical mechanics; anion and ligand exchange - innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition.

UNIT V

Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects.

UNIT VI

Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

UNIT VII

Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments.

UNIT VIII

Chemistry and electrochemistry of submerged soils.

Practical

Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the serial potentiometric titration method, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil

humic and fulvic acids by visible spectrophotometric studies and the " (E4/E6) values at two pH values, Adsorption-desorption of phosphate/sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by BaCl2-TEA method, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil

Suggested Readings

Bear RE. 1964. *Chemistry of the Soil.* Oxford and IBH.

Bolt GH & Bruggenwert MGM. 1978. *Soil Chemistry.* Elsevier.

Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes.* John Wiley & Sons.

Greenland DJ & Hayes MHB. *Chemistry of Soil Constituents.* John Wiley & Sons.

McBride MB. 1994. *Environmental Chemistry of Soils.* Oxford Univ. Press.

Sposito G. 1981. *The Thermodynamics of Soil Solutions.* Oxford Univ. Press.

Sposito G. 1984. *The Surface Chemistry of Soils.* Oxford Univ. Press.

Sposito G. 1989. *The Chemistry of Soils.* Oxford Univ. Press.

Stevenson FJ. 1994. *Humus Chemistry.* 2nd Ed. John Wiley & Sons.

Van Olphan H. 1977. *Introduction to Clay Colloid Chemistry.* John Wiley & Sons.

SOILS 504   SOIL MINERALOGY, GENESIS, CLASSIFICATION AND SURVEY   2+1

Objective

To acquaint students with basic structure of alumino-silicate minerals and genesis of clay minerals; soil genesis in terms of factors and processes of soil formation, and to enable students conduct soil survey and interpret soil survey reports in terms of land use planning.

Theory

UNIT I

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

UNIT II

Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils.

UNIT III

Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

UNIT IV

Concept of soil individual; soil classification systems - historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness.

UNIT V

Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps.

UNIT VI

Landform – soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT) – concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

Practical

Identification and quantification of minerals in soil fractions, Morphological properties of soil profile in different landforms, Classification of soils using soil taxonomy, Calculation of weathering indices and its application in soil formation, Grouping soils using available data base in terms of soil quality, Aerial photo and satellite data interpretation for soil and land use, Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales, Land use planning exercises using conventional and RS tools

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils.* 13th Ed. Pearson Edu.

Buol EW, Hole ED, MacCracken RJ & Southard RJ. 1997. *Soil Genesis and Classification.* 4th Ed. Panima Publ.

Dixon JB & Weed SB. 1989. *Minerals in Soil Environments.* 2nd Ed. Soil Science Society of America, Madison.

Grim RE. 1968. *Clay Mineralogy.* McGraw Hill.

Indian Society of Soil Science 2002. *Fundamentals of Soil Science.* ISSS, New Delhi.

Sehgal J. 2002. *Introductory Pedology: Concepts and Applications.* New Delhi

Sehgal J. 2002. *Pedology - Concepts and Applications.* Kalyani.

USDA. 1999. *Soil Taxonomy.* Hand Book No. 436. 2nd Ed. USDA NRCS, Washington.

Wade FA & Mattox RB. 1960. *Elements of Crystallography and Mineralogy.* Oxford & IBH.

Wilding LP & Smeck NE. 1983. *Pedogenesis and Soil Taxonomy.* II. *The Soil Orders.* Elsevier.

Wilding NE & Holl GF. (Eds.). 1983. *Pedogenesis and Soil Taxonomy.* I. *Concept and Interaction.* Elsevier.

SOILS 505   SOIL EROSION AND CONSERVATION   2+1

Objective

To enable students to understand various types of soil erosion and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

UNIT I

History, distribution, identification and description of soil erosion problems in India.

UNIT II

Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity - estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation.

UNIT III

Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

UNIT IV

Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout.

UNIT V

Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands.

UNIT VI

Watershed management - concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds.

Practical

Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index, Computation of kinetic energy of falling rain drops, Computation of rainfall erosivity index (EI30) using rain gauge data, Visits to a watersheds

Suggested Readings

Biswas TD & Narayanasamy G. (Eds.) 1996. *Soil Management in Relation to Land Degradation and Environment*. Bull. Indian Society of Soil Science No. 17.

Doran JW & Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil

Science Society of America, Spl Publ. No. 49, Madison, USA.

Gurmal Singh, Venkataramanan C, Sastry G & Joshi BP. 1990. *Manual of*

Soil and Water Conservation Practices. Oxford & IBH.

Hudson N. 1995. *Soil Conservation*. Iowa State Univ. Press.

Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

Oswal MC. 1994. *Soil Physics*. Oxford & IBH.

Objective

To teach students the basics of soil biology and biochemistry, including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

UNIT I

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

UNIT II

Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora.

UNIT III

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients.

UNIT IV

Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

UNIT V

Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost.

UNIT VI

Biofertilizers – definition, classification, specifications, method of production and role in crop production.

Practical

Determination of soil microbial population, Soil microbial biomass, Elemental composition, fractionation of organic matter and functional groups, Decomposition of organic matter in soil, Soil enzymes, Measurement of important soil microbial processes such as ammonification, nitrification, N2 fixation, S oxidation, P solubilization and mineralization of other micro nutrients, Study of rhizosphere effect

Suggested Readings

Alexander M. 1977. *Introduction to Soil Microbiology*. John Wiley & Sons.

Burges A & Raw F. 1967. *Soil Biology*. Academic Press.

McLaren AD & Peterson GH. 1967. *Soil Biochemistry*. Vol. XI. Marcel Dekker.

Metting FB. 1993. *Soil Microbial Ecology – Applications in Agricultural and Environmental Management*. Marcel Dekker.

Paul EA & Ladd JN. 1981. *Soil Biochemistry*. Marcel Dekker.

Reddy MV. (Ed.). *Soil Organisms and Litter in the Tropics*. Oxford & IBH.

Russel RS. 1977. *Plant Root System: Their Functions and Interaction with the Soil*. ELBS & McGraw Hill.

Stotzky G & Bollag JM. 1993. *Soil Biochemistry*. Vol. VIII. Marcel Dekker.

Sylvia DN. 2005. *Principles and Applications of Soil Microbiology*. Pearson Edu.

Wild A. 1993. *Soil and the Environment - An Introduction*. Cambridge Univ. Press.

SOILS 507　　　　GEOMORPHOLOGY AND GEOCHEMISTRY　　　　2+0

Objective

To impart knowledge about the landforms, physiography and morphology of the earth surface, and distribution and weathering elements in the earth crust.

Theory

UNIT I

General introduction to geology and geochemistry, major and minor morphogenic and genetic landforms, study of schematic landforms and their elements with special reference to India.

UNIT II

Methodology of geomorphology, its agencies, erosion and weathering; soil and physiography relationships; erosion surface of soil landscape.

UNIT III

Geochemical classification of elements; geo-chemical aspects of weathering and migration of elements; geochemistry of major and micronutrients and trace elements.

Suggested Readings

Brikland PW. 1999. *Soils and Geomorophology*. 3rd Ed. Oxford Univ. Press.

Likens GE & Bormann FH. 1995. *Geochemistry*. 2nd Ed. Springer Verlag.

Mortvedt JJ, Shuman LM, Cox FR & Welch RM. 1991. *Micronutrients in Agriculture*. 2nd Ed. SSSA, Madison.

SOILS 508　　　RADIO ISOTOPES IN SOIL AND PLANT STUDIES　　　1+1

Objective

To train students in the use of radioisotopes in soil and plant research

Theory

UNIT I

Atomic structure, radioactivity and units; radioisotopes - properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter

UNIT II

Principles and use of radiation monitoring instruments - proportional, Geiger Muller counter, solid and liquid scintillation counters; neutron moisture meter, mass spectrometry, auto radiography

UNIT III

Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating

UNIT IV

Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes

Practical

Storage and handling of radioactive materials, Determination of half life and decay constant, Preparation of soil and plant samples for radioactive measurements, Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radioisotopes, Determination of A, E and L values of soil using 32P/ 65Zn, Use of neutron probe for moisture determination, Sample preparation and measurement of 15N enrichment by mass spectrophotometery/ emission spectrometry

Suggested Readings

Comer CL. 1955. *Radioisotopes in Biology and Agriculture: Principles and Practice.* Tata McGraw Hill.

Glasstone S. 1967. *Source Book on Atomic Energy.* East West Press.

Michael FL & Annunziata. 2003. *Handbook of Radioactivity Analysis.* Academic Press.

SOILS 509	SOIL, WATER AND AIR POLLUTION	2+1

Objective

To make the students aware of the problems of soil, water and air pollution associated with use of soils for crop production.

Theory

UNIT I

Soil, water and air pollution problems associated with agriculture, nature and extent.

UNIT II

Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants - their CPC standards and effect on plants, animals and human beings.

UNIT III

Sewage and industrial effluents – their composition and effect on soil properties/health, and plant growth and human beings; soil as sink for waste disposal.

UNIT IV

Pesticides – their classification, behavior in soil and effect on soil microorganisms.

UNIT V

Toxic elements – their sources, behavior in soils, effect on nutrients availability, effect on plant and human health.

UNIT VI

Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases – carbon dioxide, methane and nitrous oxide.

UNIT VIII

Remediation/amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

Sampling of sewage waters, sewage sludge, solid/liquid industrial wastes, polluted soils and plants, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safeguard food safety, Air sampling and determination of particulate matter and oxides of sulphur, Visit to various industrial sites to study the impact of pollutants on soil and plants

Suggested Readings

Lal R, Kimble J, Levine E & Stewart BA. 1995. *Soil Management and Greenhouse Effect.* CRC Press.

Middlebrooks EJ. 1979. *Industrial Pollution Control.* Vol. I. *Agro- Industries.* John Wiley Interscience.

Ross SM. *Toxic Metals in Soil Plant Systems.* John Wiley & Sons.

Vesilund PA & Pierce 1983. *Environmental Pollution and Control.* Ann Arbor Science Publ.

SOILS 510	REMOTE SENSING AND GIS TECHNIQUES FOR	2+1
	SOIL, WATER AND CROP STUDIES	

Objective

To impart knowledge about the basic concepts of remote sensing, aerial photographs and imageries, and their interpretation; application of remote sensing in general and with special reference to soil, plants and yield forecasting; to impart knowledge about geo-statistical techniques with special reference to krigging, and GIS and applications in agriculture.

Theory

UNIT I

Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter.

UNIT II

Sensor systems - camera, microwave radiometers and scanners; fundamentals of aerial photographs and image processing and interpretations.

UNIT III

Application of remote sensing techniques - land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, wasteland identification and management.

UNIT IV

Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

UNIT V

Introduction to GIS and its application for spatial and non-spatial soil and land attributes.

Practical

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photographs and satellite data for mapping of land resources, Analysis of variability of different soil properties with classical and geostatistical techniques, Creation of data files in a database programme, Use of GIS for soil spatial simulation and analysis, To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.

Elangovan K. 2006. *GIS Fundamentals, Applications and Implementations*. New India Publ. Agency.

Lillesand TM & Kiefer RW. 1994. *Remote Sensing and Image Interpretation*. 3rd Ed. Wiley.

Nielsen DR & Wendroth O. 2003. *Spatial and Temporal Statistics*. Catena Verloggmbh.

Star J & Esles J. 1990. *Geographic Information System: An Introduction*. Prentice Hall.

SOILS 511	ANALYTICAL TECHNIQUES AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS	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

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidationreduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling. Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils. Principles of visible,

ultraviolet and infrared spectrophotometery, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractometery; identification of minerals by X-ray by different methods. 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. 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. Determination of lime and gypsum requirement of soil; drawing normalized exchange isotherms; measurement of redox potential. 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.

SOILS 512　　SYSTEM APPROACHES IN SOIL AND CROP STUDIES　　2+1

Objective

To train the students in concepts, methodology, technology and use of systems simulation in soil and crops studies.

Theory

UNIT I

Systems concepts - definitions, general characteristics; general systems theory; systems thinking, systems dynamics, systems behavior and systems study.

UNIT II

Model: definition and types; mathematical models and their types; modeling: concepts, objectives, processes, abstraction techniques; simulation models, their verification and

validation, calibration; representation of continuous systems simulation models - procedural and declarative.

UNIT III

Simulation - meaning and threats; simulation experiment, its design and analysis.

UNIT IV

Application of simulation models in understanding system behavior, optimizing system performance, evaluation of policy options under different soil, water, nutrient, climatic and cultural conditions; decision support system, use of simulation models in decision support system.

Practical

Use of flow chart or pseudo-code in the program writing, Writing a small example simulation model program - declarative (in Vensim PLE, Stella or Simile) and procedural (in Java, Fortran, QBasic or V Basic), Conducting simulation experiments in DSSAT, WOFOST or EPIC with requirement of report and conclusion

Suggested Readings

Benbi DK & Nieder R. (Eds.). 2003. *Handbook of Processes and Modelling in the Soil - Plant System*. Haworth Press.

Hanks J & Ritchie JT. (Eds.). 1991. *Modelling Plant and Soil System*.

Agronomy. Bull. No 31. Soil Sci. Society of America, Madison.

Rajaraman V. 2004. *Computer Programming in Fortran 90 and 95*. PHI.

Tsuji GY, Gerrit H & Philip T. 1998. *Understanding Options for Agricultural Production*. Kluwer.von Bertalanffy Ludwig 1969. *General Systems Theory: Foundation Development and Application*. Revised Ed. George Braziller Reprint 1998.

Web sites

Documentation of the respective models. (http://www.simulistics.com/ for Simile; http://www.iseesystems.com for Stella; and

http://www.vensim.com/software.html for vensim PLE)

http://www.icasa.net/dssat/index.html for DSSAT;

http://www.brc.tamus.edu/epic/ for EPIC

http://www.nrel.colostate.edu/projects/century/ for Century

http://www.alterra.wur.nl/NL/for WOFOST

http://www.apsru.gov.au/ apsru/Default.htm for APSIM

http://eco.wiz.uni-kassel.de/ecobas.html online Register of ecological

models

Plentinger MC Penning de Vries FWT, Editors (1996) CAMASE

Register of Agro-ecosystems Models. DLO-Research Institute for

Agrobiology and Soil Fertility (AB-DLO)

Agricultural Systems – Elsevier at

http://www.elsevier.com/wps/product/cws_home /405851

Ecological Modeling – Elsevier at

http://www.elsevier.com/locate/ecolmodel

SOILS 513   MANAGEMENT OF PROBLEM SOILS AND WATERS   2+1

Objective

To educate students about basic concepts of problem soils and brackish water, and their management. Attention will be on management of problem soils and safe use of brackish water in relation to crop production.

Theory

UNIT I

Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.

UNIT II

Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties.

UNIT III

Management of salt-affected soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils.

UNIT IV

Acid soils - nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management.

UNIT V

Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

UNIT VI

Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

Practical

Characterization of acid, acid sulfate, salt-affected and calcareous soils, Determination of cations (Na+, K+, Ca++ and Mg++) in ground water and soil samples, Determination of anions (Cl-, SO4—, CO3— and HCO3-) in ground waters and soil samples, Lime and gypsum requirements of acid and sodic soils

Suggested Readings

Bear FE. 1964. *Chemistry of the Soil*. Oxford & IBH.

Jurinak JJ. 1978. *Salt-affected Soils*. Department of Soil Science & Biometeorology. Utah State Univ.

USDA Handbook No. 60. 1954. *Diagnosis and improvement of Saline and Alkali Soils*. Oxford & IBH.

SOILS 514   **FERTILIZER TECHNOLOGY**   **1+0**

Objective

To impart knowledge about how different fertilizers are manufactured using different kinds of raw materials and handling of fertilizers and manures.

Theory

UNIT I

Fertilizers – production, consumption and future projections with regard to nutrient use in the country and respective states; fertilizer control order.

UNIT II

Manufacturing processes for different fertilizers using various raw materials, characteristics and nutrient contents.

UNIT III

Recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order.

UNIT IV

New and emerging issues in fertilizer technology – production and use of slow and controlled release fertilizers, supergranules fertilizers and fertilizers for specific crops/situations.

Suggested Readings

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils.* Pearson Edu.

Fertilizer (Control) Order, 1985 and the Essential Commodities Act. FAI New Delhi.

Kanwar JS. (Ed.). 1976. *Soil Fertility: Theory and Practice.* ICAR.

Olson RA, Army TS, Hanway JJ & Kilmer VJ. 1971. *Fertilizer Technology and Use.* 2nd Ed. Soil Sci. Soc. Am. Madison.

Prasad R & Power JF. *Soil Fertility Management for Sustainable Agriculture.* CRC Press.

Tisdale SL, Nelson SL, Beaton JD & Havlin JL. 1999. *Soil Fertility and Fertilizers.* McMillan Publ.

Vogel AI. 1979. *Textbook of Quantitative Inorganic Analysis.* ELBS.

SOILS 515   **LAND DEGRADATION AND RESTORATION**   **1+0**

Objective

To impart knowledge related to various factors and processes of land degradation and their restoration techniques.

Theory

UNIT I

Type, factors and processes of soil/land degradation and its impact on soil productivity, including soil fauna, biodegradation and environment.

UNIT II

Land restoration and conservation techniques - erosion control, reclamation of salt-affected soils; mine land reclamation, afforestation, organic products.

UNIT III

Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.

Suggested Readings

Biswas TD & Narayanasamy G. (Eds.). 1996. *Soil Management in Relation* to Land Degradation and Environment. Bull. Indian Soc. Soil Sci. 17, New Delhi.

Doran JW & Jones AJ. 1996. *Methods of Assessing Soil Quality*. Soil Science Society of America, Madison.

Greenland DJ & Szabolcs I. 1994. *Soil Resilience and Sustainable Land Use*. CABI.

Lal R, Blum WEH, Vailentine C & Stewart BA. 1997. *Methods for Assessment of Soil Degradation*. CRC Press.

Sehgal J & Abrol IP. 1994. *Soil Degradation in India - Status and Impact*. Oxford & IBH.

SOILS 601	ADVANCES IN SOIL PHYSICS	2+0

Objective

To provide knowledge of modern concepts in soil physics.

Theory

UNIT I

Soil-water interactions, soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system.

UNIT II

Fundamentals of fluid flow, Poiseuilles law, Laplace's equation, Darcy's law in saturated and unsaturated flows; development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; limitations of Darcy's law; numerical solution for one dimensional water flow.

UNIT III

Theories of horizontal and vertical infiltration under different boundary conditions.

UNIT IV

Movement of salts in soils, models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves.

UNIT V

Soil air and aeration, mass flow and diffusion processes; thermal properties of soil, heat transfer in soils, differential equation of heat flow, measurement of thermal conductivity of soil.

UNIT VI

Soil crust and clod formation; structural management of puddled rice soils; soil conditioning-concept, soils conditioners - types, characteristics, working principles, significance in agriculture.

UNIT VII

Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluation of soil and plant water status using infra-red thermometer.

Suggested Readings

Baver LD, Gardner WH & Gardner WR. 1972. *Soil Physics*. John Wiley & Sons.

Hanks and Ascheroft. 1980. *Applied Soil Physics*. Springer Verlag.

Hillel D. 1980. *Applications of Soil Physics*. Academic Press.

Hillel D. 1980. *Environmental Soil Physics*. Academic Press.

Indian Society of Soil Science 2002. *Fundamentals of Soil Science*. ISSS, New Delhi.

Kirkham D & Powers WL. 1972. *Advanced Soil Physics*. Wiley Interscience.

Lal R & Shukla MK. 2004. *Principles of Soil Physics*. Marcel Dekker.

Oswal MC.1994. *Soil Physics*. Oxford & IBH.

| SOILS 602 | ADVANCES IN SOIL FERTILITY | 2+0 |

Objective

To provide knowledge of modern concepts of soil fertility and nutrient use in crop production.

Theory

UNIT I

Modern concepts of nutrient availability; soil solution and plant growth; nutrient response functions and availability indices.

UNIT II

Nutrient movement in soils; nutrient absorption by plants; mechanistic approach to nutrient supply and uptake by plants; models for transformation and movement of major micronutrients in soils.

UNIT III

Chemical equilibria (including solid-solution equilbria) involving nutrient ions in soils, particularly in submerged soils.

UNIT IV

Modern concepts of fertilizer evaluation, nutrient use efficiency and nutrient budgeting.

UNIT V

Modern concepts in fertilizer application; soil fertility evaluation techniques; role of soil tests in fertilizer use recommendations; site-specific nutrient management for precision agriculture.

UNIT VI

Monitoring physical, chemical and biological changes in soils; permanent manurial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Suggested Readings

Barber SA. 1995. *Soil Nutrient Bioavailability*. John Wiley & Sons.

Barker V Allen & Pilbeam David J. 2007. *Handbook of Plant Nutrition.*

CRC / Taylor & Francis.

Brady NC & Weil RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Educ.

Cooke GW. 1979. *The Control of Soil Fertility*. Crossby Lockwood & Sons.

Epstein E. 1987. *Mineral Nutrition of Plants - Principles and Perspectives.*

International Potash Institute, Switzerland.

Kabata- Pendias Alina 2001. *Trace Elements in Soils and Plants*. CRC / Taylor & Francis.

Kannaiyan S, Kumar K & Govindarajan K. 2004. *Biofertilizers Technology*. Scientific Publ.

Mortvedt JJ, Shuman LM, Cox FR & Welch RM. (Eds.). 1991.

Micronutrients in Agriculture. 2nd Ed. Soil Science Society of America, Madison.

Prasad R & Power JF. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

Stevenson FJ & Cole MA. 1999. *Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulphur, Micronutrients*. John Wiley & Sons.

Stevenson FJ. (Ed.). 1982. *Nitrogen in Agricultural Soils*. Soil Science Society of America, Madison.

Tisdale SL, Nelson WL, Beaton JD & Havlin JL. 1990. *Soil Fertility and Fertilizers*. 5th Ed. Macmillan Publ.

Wild A. (Ed.). 1988. *Russell's Soil Conditions and Plant Growth*. 11th Ed. Longman.

SOILS 603   PHYSICAL CHEMISTRY OF SOILS   2+0

Objective

To impart knowledge about modern concepts of physical chemistry of soils and clays, with emphasis on understanding the processes involved with practical significance.

Theory

UNIT I

Colloidal chemistry of inorganic and organic components of soils - their formation, clay organic interaction.

UNIT II

Predictive approaches for cation exchange equilibria - thermodynamics, empirical and diffuse double layer theory (DDL) - relationships among different selectivity coefficients; structure and properties of diffuse double layer.

UNIT III

Thermodynamics of nutrient transformations in soils; cationic and anionic exchange and their models, molecular interaction.

UNIT IV

Adsorption/desorption isotherms - Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials (citation of utility in agricultural system).

UNIT V

Common solubility equilibria - carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate; electrochemical properties of clays (citation of examples from agricultural use).

Suggested Readings

Bear RE. 1964. *Chemistry of the Soil*. Oxford & IBH.

Bolt GH & Bruggenwert MGM. 1978. *Soil Chemistry*. Elsevier.

Fried M & Broeshart H. 1967. *Soil Plant System in Relation to Inorganic Nutrition*. Academic Press.

Greenland DJ & Hayes MHB. 1981. *Chemistry of Soil Processes*. John Wiley & Sons.

Greenland DJ & Hayes MHB. 1978. *Chemistry of Soil Constituents*. John Wiley & Sons.

Jurinak JJ. 1978. *Chemistry of Aquatic Systems*. Dept. of Soil Science & Biometeorology, Utah State Univ.

McBride MB. 1994. *Environmental Chemistry of Soils*. Oxford Univ. Press.

Sparks DL. 1999. *Soil Physical Chemistry*. 2nd Ed. CRC Press.

Sposito G. 1981. *The Thermodynamics of Soil Solutions*. Oxford Univ. Press.

Sposito G. 1984. *The Surface Chemistry of Soils*. Oxford Univ. Press.

Sposito G. 1989. *The Chemistry of Soils*. Oxford Univ. Press.

Stevenson FJ. 1994. *Humus Chemistry*. 2nd Ed. John Wiley.

van Olphan H. 1977. *Introduction to Clay Colloid Chemistry*. John Wiley & Sons.

SOILS 604   **SOIL GENESIS AND MICROPEDOLOGY**   **2+0**

Objective

To impart knowledge about the pedogenic processes in soils and to acquaint with the micro-pedological study of soil profile.

Theory

UNIT I

Pedogenic evolution of soils; soil composition and characterization.

UNIT II

Weathering and soil formation – factors and pedogenic processes; stability and weathering sequences of minerals.

UNIT III

Assessment of soil profile development by mineralogical and chemical analysis.

UNIT IV

Micro-pedological features of soils – their structure, fabric analysis, role in genesis and classification.

Suggested Readings

Boul SW, Hole ED, MacCraken RJ & Southard RJ. 1997. *Soil Genesis and Classification*. 4th Ed. Panima Publ.

Brewer R. 1976. *Fabric and Mineral Analysis of Soils*. John Wiley & Sons.

SOILS 605   BIOCHEMISTRY OF SOIL ORGANIC MATTER   2+0

Objective

To impart knowledge related to chemistry and reactions of organic substances and their significance in soils.

Theory

UNIT I

Organic matter pools in soil; composition and distribution of organic matter in soil and its functions; environmental significance of humic substances; decomposition of organic residues in soil in relation to organic matter pools.

UNIT II

Biochemistry of the humus formation; different pathways for humus synthesis in soil; soil carbohydrates and lipids.

UNIT III

Nutrient transformation – N, P, S; trace metal interaction with humic substances, significance of chelation reactions in soils.

UNIT IV

Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pathogenic soil aggregation processes; clay-organic matter complexes.

UNIT V

Humus - pesticide interactions in soil, mechanisms.

Suggested Readings

Beck AJ, Jones KC, Hayes MHB & Mingelgrin U. 1993. Organic

Substances in Soil and Water: Natural Constituents and their

Influences on Contaminant Behavior. Royal Society of Chemistry, London.

Gieseking JE. 1975. *Soil Components*. Vol. 1. *Organic Components*. Springer-Verlag.

Kristiansen P, Taji A & Reganold J. 2006. *Organic Agriculture: A Global Perspective*. CSIRO Publ.

Magdoff F & Weil RR 2004. *Soil Organic Matter in Sustainable Agriculture*. CRC Press.

Mercky R & Mulongoy K. 1991. *Soil Organic Matter Dynamics and Sustainability of Tropical Agriculture*. John Wiley & Sons.

Paul EA. 1996. *Soil Microbiology and Biochemistry*. Academic Press.

Stevenson FJ. 1994. *Humus Chemistry – Genesis, Composition and Reactions*. John Wiley && Sons.

SOILS 606   LAND USE PLANNING AND WATERSHED MANAGEMENT   2+0

Objective

To teach the better utilization of land for agricultural purposes, and better management of run-off or surplus/excessive rain-water in the catchment area for agricultural purposes in a watershed.

Theory

UNIT I

Concept and techniques of land use planning; factors governing present land use.

UNIT II

Land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application.

UNIT III

Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production.

UNIT IV

Water harvesting - concept, significance, types, methodology; use of harvested water in agriculture to increase water productivity.

UNIT V

Watershed development/management - concept, objectives, characterization, planning, execution, community participation and evaluation; rehabilitation of watershed; PRA; developing economically and ecologically sustainable agro-forestry systems for watershed; case studies.

Suggested Readings

All India Soil and Land Use Survey Organisation 1970. *Soil Survey Manual*. IARI, New Delhi.

FAO. 1976. *A Framework for Land Evaluation*, Handbook 32. FAO.

Sehgal JL, Mandal DK, Mandal C & Vadivelu S. 1990. *Agro-Ecological Regions of India*. NBSS & LUP, Nagpur.

Soil Survey Staff 1998. *Keys to Soil Taxonomy*. 8th Ed. USDA & NRCS, Washington, DC.

USDA 1974. *A Manual on Conservation of Soil and Water Handbook of Professional Agricultural Workers*. Oxford & IBH.

List of Journals

Advances in Agronomy

Annals of Arid Zone

Australian Journal of Agricultural Research

Australian Journal of Soil Research

Biology and Fertility of Soils

Communications in Soil Science and Plant Analysis

Clays and Clay minerals

European Journal of Soil Science

Geoderma

Indian Journal of Agricultural Sciences

Journal of Plant Nutrition and Soil Science

Journal of the Indian Society of Soil Science

Nutrient Cycling in Agroecosystems

Plant and Soil

Soil and Tillage Research

Soil Biology and Biochemistry

Soil Science

Soil Science Society of America Journal

Soil Use and Management

Water, Air and Soil Pollution

Water Resources Research

Suggested Broad Topics for Master's and Doctoral Research

Degradation and restoration of soil as natural resource

Biochemistry of processes at the soil-root interface

Impact of current agricultural practices and agrochemicals on soil quality/biodiversity

Integrated nutrient management for sustainable agriculture

Fertilizer use efficiency in different soil conditions/cropping systems

Use of remote sensing and GIS as diagnostic tool for natural resource management

Role of biological agents in soil productivity

Modeling solute (salt, fertilizer, pesticides) transport in soil

Use of poor quality waters in Agriculture

Soil testing and crop response

Site-specific nutrient management and precision agriculture

Nutrient dynamics in soil-plant system and modeling nutrient uptake

Tillage and crop residue management in crop production

Utilization of urban and industrial wastes/effluents in Agriculture

Management of problematic soils

Impact of climate change on soil processes

Micronutrients in soil, plant and human health

Water management strategies in different cropping systems

Simulation models for growth and production of different crops

Varietals response to soil salinity/ sodicity/ nutrients/ pollutants, etc

Soil and water pollution - monitoring and control

Genesis, formation and classification of soils

Soil conservation, preservation and management for sustainable agriculture

Remediation of polluted and contaminated soils

STATISTICS AND MATHEMATICS
Course Structure – at a Glance

CODE	COURSE TITLE	CREDITS
STAT 501	MATHEMATICAL METHODS FOR APPLIED SCIENCES	1+1
STAT 511	STATISTICAL METHODS FOR APPLIED SCIENCES	2+1
STAT 512	EXPERIMENTAL DESIGNS	2+1
STAT 513	SAMPLING TECHNIQUES	2+1
STAT 521	APPLIED REGRESSION ANALYSIS	2+1
STAT 531	DATA ANALYSIS USING STATISTICAL PACKAGES	2+1
STAT 560*	PROBABILITY THEORY	2+0
STAT 561*	STATISTICAL METHODS	2+1
STAT 562*	STATISTICAL INFERENCE	2+1
STAT 563*	MULTIVARIATE ANALYSIS	2+1
STAT 564*	DESIGN OF EXPERIMENTS	2+1
STAT 565*	SAMPLING TECHNIQUES	2+1
STAT 566*	STATISTICAL GENETICS	2+1
STAT 567*	REGRESSION ANALYSIS	2+1
STAT 568*	STATISTICAL COMPUTING	1+1
STAT 569*	TIME SERIES ANALYSIS	1+1
STAT 570	ACTUARIAL STATISTICS	1+1
STAT 571	BIOINFORMATICS	1+1
STAT 572	ECONOMETRICS	1+1
STAT 573	STATISTICAL QUALITY CONTROL	1+1
STAT 574	OPTIMIZATION TECHNIQUES	1+1
STAT 575	DEMOGRAPHY	1+1
STAT 576	STATISTICAL METHODS FOR LIFE SCIENCES	1+1
STAT 577	STATISTICAL ECOLOGY	1+1
STAT 591	MASTER'S SEMINAR	1+0
STAT 599	MASTER'S RESEARCH	20
STAT 551	MATHEMATICAL METHODS - I	2+1
STAT 552	MATHEMATICAL METHODS - II	1+1

* Compulsory for Master's programme

Minor Departments   9

Computers

Agricultural Economics

Supporting Departments   5

Statistics and Mathematics

Non credit compulsory courses

CODE	COURSE TITLE	CREDITS
PGS 501	LIBRARY AND INFORMATION SERVICES	0+1
PGS 502	TECHNICAL WRITING AND COMMUNICATION SKILLS	0+1
PGS 503 (e-course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0
PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1
PGS 505 (e-course)	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0
PGS 506 (e-course)	DISASTER MANAGEMENT	1+0

MATHEMATICAL METHODS FOR APPLIED SCIENCES

Objective

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses.

Theory

UNIT I

Variables and functions; Limit and continuity, Specific functions, Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, function of a function, derivative of higher order, partial derivatives, application of derivatives in agricultural research; determination of points of inflexion, maxima and minima in optimization, etc.

UNIT II

Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral; Applications of integration in agricultural research with special reference to economics and genetics, engineering, etc.

UNIT III

Vectors and vector spaces, Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; Eigen values and Eigen vectors; Determinants - evaluation and properties of determinants, application of determinants and matrices in solution of equation for economic analysis.

UNIT IV

Set theory-set operations, finite and infinite sets, operations of set, function defined in terms of sets.

Practical

Problems on Product and Quotient Rule, logarithmic and exponential functions, trigonometric and inverse functions; function of a function, derivative of higher order and partial derivatives; Application of derivatives in agricultural research- determination of points of inflexion, maxima and minima in optimization, etc; Integration as a reverse process of differentiation -methods of integration, reduction formulae and definite integral; Applications of integration-Area, Consumer and Producer Surplus; Problems on Matrices, notations and operations, laws of matrix algebra; Problems on Determinants; transpose and inverse of matrix; Eigen values and eigen vectors; solution of equation for economic analysis.

References

Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective.*, Springer.

Hohn FE. 1973. *Elementary Matrix Algebra*. Macmillan.

Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.

Stewart J. 2007. *Calculus*. Thompson.

Thomas GB. Jr. & Finney RL. 1996. *Calculus*. 9th Ed. Pearson Edu.

Objective

This course is developed to provide exposure of statistical methods to the students who do not have sufficient background of statistics. The students would be exposed to the basic statistical methods which include probability, estimation, tests of significance and correlation and regression.

Theory

UNIT I

Classification, Tabulation and Graphical Representation of data, Box-Plot and Descriptive Statistics, Exploratory data analysis; Theory of Probability-Random Variable and Mathematical Expectation

UNIT II

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

UNIT III

Introduction to theory of estimation and confidence intervals; Correlation and regression, Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients, Coefficient of Determination, Testing for heterogeneity.

UNIT IV

Non-parametric tests - Sign, Wilcoxon, Mann-Whitney U-test and Wald-Wolfowitz run test; Run test for the randomness of a sequence. Median test, Kruskal-Wallis test, Friedman two-way ANOVA by ranks and Kendall's coefficient of concordance.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions ~ Binomial, Poisson and Normal; Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F; Confidence interval estimation and point estimation of parameters of Binomial, Poisson and Normal distribution; Correlation and regression analysis; Nonparametric tests.

References

Goon AM, Gupta MK & Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.

Goon AM, Gupta MK & Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.

Hoel PG. 1971. *Introduction to Mathematical Statistics*. John Wiley.

Hogg RV & Craig TT. 1978. *Introduction to Mathematical Statistics*. Macmillan.

Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.

Learning Statistics: http://freestatistics.altervista.org/en/learning.php-

Electronic Statistics Text Book: http://www.statsoft.com/textbook/stathome.html.

Objective

This course is developed to meet the requirements of students of agriculture and animal sciences *other than* Statistics. The students would be exposed to the techniques of planning, designing of experiments as well as 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), 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, Lattice Design - concepts, randomization procedure, analysis and interpretation of results. Response Curves and Surfaces, Experiments with mixtures.

UNIT V

Introduction to Bio-assays with applications- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD and 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 Curves and Surfaces.

References

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 Publ.

Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.

Design Resources Server: www.iasri.res.in/design.

STAT 513　　　　　　　　SAMPLING TECHNIQUES　　　　　　　　2+1

Objective

This course is developed to meet the requirements of students of agriculture and animal sciences **other than** Statistics. The students would be exposed to the elementary sampling techniques, which would help them in understanding the concepts involved in planning and designing their surveys.

Theory

UNIT I

Concept of Sampling: Sample Survey *vs.* complete enumeration, planning of sample survey, sampling from a finite population.

UNIT II

Simple Random Sampling, Sampling for proportion, determination of sample size; inverse sampling, Stratified sampling.

UNIT III

Cluster Sampling, PPS Sampling, Multi-Stage Sampling, Double Sampling, Systematic Sampling; Use of auxiliary information at estimation as well as selection stages.

UNIT IV

Ratio and Regression Estimators, Sampling and Non-Sampling Errors; Preparation of Questionnaire and Non-Sampling errors

Practical

Random Sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.; simple random sampling, determination of sample size; Exercises on inverse sampling, stratified sampling, cluster sampling and systematic sampling; Estimation using ratio and regression estimators; Estimation using multistage design, double sampling and PPS sampling.

References

Cochran WG. 1977. *Sampling Techniques*. John Wiley

Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.

Singh D, Singh P & Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.

Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.

STAT 521　　　　　　　APPLIED REGRESSION ANALYSIS　　　　　　　2+1

Objective

This course is developed to meet the requirements of students of agriculture and animal sciences. The students would be exposed to the concepts of correlation and regression with special emphasis on diagnostic measures such as Autocorrelation, Multicollinearity and Heteroscedasticity.

Theory

UNIT I

Introduction to Correlation Analysis and its measures; Correlation from grouped data, Biserial correlation, Rank correlation; Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing

UNIT II

Autocorrelation; Durbin Watson Statistics; Analysis of collinear data; Detection and correction of Multicollinearity; Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

UNIT III

Examining the Multiple Regression Equation, Concept of Weighted Least Squares, Regression equation on grouped data; various methods of selecting the best regression equation.

UNIT IV

Heteroscedastic Models, Concept of Non-Linear Regression and fitting of Quadratic Curves; Economic and optimal dose, Orthogonal polynomial

Practical

Correlation Coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, Multicollinearity, Fitting of Quadratic Curves, Fitting of orthogonal polynomials.

References

Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.

Ezekiel M. 1963. *Methods of Correlation and Regression Analysis*. John Wiley.

Kleinbaum DG, Kupper LL, Muller KE & Nizam A. 1998. *Applied Regression Analysis and Multivariable Methods*. Duxbury Press.

Kutner MH, Nachtsheim CJ & Neter J. 2004. *Applied Linear Regression Models*. 4th Ed. With Student CD. McGraw Hill.

STAT 531   DATA ANALYSIS USING STATISTICAL PACKAGES   2+1

Objective

This course provides exposure to the students in use of various statistical packages for analysis of data. It provides hands on experience in the analysis of research data.

Theory

UNIT I

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II

Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, *t* and *F* statistics.

UNIT III

Concept of Analysis Of Variance and Covariance of data for single factor, multi-factor, One-Way and Two-way classified experiments, multiple comparisons

UNIT IV

ANOVA Models- Estimation of Variance Components; testing Correlation and Regression including Multiple Regression

UNIT V

Discriminant function; Factor analysis; Principal component analysis, fitting of non-linear models; Time series data

Practical

Use of software packages for summarization and tabulation of data; obtaining descriptive statistics, graphical representation of data, Robust Estimation, Testing linearity and normality assumption, Cross tabulation of data including its statistics, cell display and table format and means for different sub-classifications; Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, One way Analysis Of Variance, pair-wise comparisons; Two-Way Analysis Of Variance, Factorial set up, fixed effect models, estimation of variance components; Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple Regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models - curve estimation models, examination of residuals; Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis, Principal Component Analysis-obtaining principal component, spectral composition; Analysis of time series data - fitting of ARIMA models.

References

Anderson CW & Loynes RM. 1987. *The Teaching of Practical Statistics*. John Wiley.

Atkinson AC. 1985. *Plots Transformations and Regression*. Oxford University Press.

Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmount, California.

Chatfield C & Collins AJ. 1980. *Introduction to Multivariate Analysis*. Chapman & Hall.

Chatfield C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall.

Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.

Cleveland WS. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.

Ehrenberg ASC. 1982. *A Primer in Data Reduction*. John Wiley. Erickson BH & Nosanchuk TA. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.

Tufte ER. 1983. *The Visual Display of Quantitative Information*. Graphics Press, Cheshire, Conn.

Velleman PF & Hoaglin DC. 1981. *Application, Basics and Computing of Exploratory Data Analysis*. Duxbury Press.

Weisberg S. 1985. *Applied Linear Regression*. John Wiley.

Wetherill GB. 1982. *Elementary Statistical Methods*. Chapman & Hall.

Wetherill GB.1986. *Regression Analysis with Applications*. Chapman & Hall.

Learning Statistics: http://freestatistics.altervista.org/en/learning.php.

Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.

Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.

Course on Experimental design:

http://www.stat.sc.edu/~grego/courses/stat706/.

Design Resources Server: www.iasri.res.in/design.

Analysis of Data: Design Resources Server.

http://www.iasri.res.in/design/Analysis%20of%20data/Analysis%20of%2 Data.html.

STAT 560   PROBABILITY THEORY   2+0

Objective

This is a fundamental course in Statistics. This course lays the foundation of probability theory, random variable, probability distribution, mathematical expectation, etc. which forms the basis of basic statistics.

Theory

UNIT I

Basic concepts of probability- Elements of measure theory: class of sets, field, sigma field, minimal sigma field, Borel sigma field in R, measure, probability measure, Axiomatic approach to probability, properties of probability based on axiomatic definition, Addition and multiplication theorems, conditional probability and independence of events; Bayes theorem.

UNIT II

Random variables: definition of random variable, discrete and continuous, functions of random variables, Probability mass function and Probability density function, Distribution function and its properties, Notion of bivariate random variables, bivariate distribution function and its properties; Joint, marginal and conditional distributions; Independence of random variables, Transformation of random variables (two dimensional case only). Mathematical expectation: Mathematical expectation of functions of a random variable, Raw and central moments and their relation, covariance, skewness and kurtosis, Addition and multiplication theorems of expectation, Definition of Moment Generating Function, Cumulating Generating Function, Probability Generating Function and statements of their properties.

UNIT III

Conditional Expectation and Conditional Variance, Characteristic function and its properties, Inversion and Uniqueness Theorems, Functions, which cannot be characteristic functions, Chebyshev, Markov, Cauchy-Schwartz, Jenson, Liapounov, Holder's and Minkowsky's inequalities, Sequence of random variables and modes of convergence (convergence in distribution, in probability, almost surely, and quadratic mean) and their interrelations. Statement of Slutsky's theorem, Borel –Cantelli lemma and Borel 0-1 law

UNIT IV

Laws of large numbers: WLLN, Bernoulli and Kintchin's WLLN. Kolmogorov inequality, Kolmogorov's SLLNs. Central Limit theorems: Demoviere- Laplace CLT, Lindberg – Levy CLT, Liapounov CLT, Statement of Lindeberg-Feller CLT and simple applications, Definition of quantiles and statement of asymptotic distribution of sample quantiles.

UNIT V

Classification of Stochastic Processes, Examples, Markov Chain and classification of States of Markov Chain

References

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STAT 561	STATISTICAL METHODS	2+1

Objective

This course lays the foundation of probability distributions and sampling distributions and their application which forms the basis of Statistical Inference. Together with probability theory, this course is fundamental to the discipline of Statistics.

Theory

UNIT I

Descriptive statistics: probability distributions: Discrete probability distributions ~ Bernoulli, Binomial, Poisson, Negative-binomial, Geometric and Hyper Geometric and Uniform Distributions ~ Properties of these distributions and real life examples, Continuous Probability Distributions ~ Rectangular, Exponential, Cauchy, Normal, Gamma, Beta, Weibull, Lognormal, Logistic and Pareto Distributions~ Properties of these distributions, Probability distributions of functions of random variables.

UNIT II

Concepts of compound, truncated and mixture distributions (definitions and examples), Pearsonian curves and its various types, Sampling distributions of sample mean and sample variance from Normal population, central and non–central chi-Square, t and F distributions, and their properties and inter relationships.

UNIT III

Concepts of random vectors, moments and their distributions, Bivariate Normal distribution - marginal and conditional distributions, Distribution of Quadratic forms, Cochran theorem, Correlation, Rank Correlation, correlation ratio and intra-class correlation, Regression Analysis, Partial and Multiple Correlation and Regression.

UNIT IV

Sampling distribution of Correlation Coefficient, Regression coefficient, Correlation Ratio, Intra class correlation coefficient, Categorical Data Analysis- loglinear models, Association between attributes. Variance Stabilizing Transformations

UNIT V

Order statistics, distribution of r-th order statistics, Joint distribution of several order statistics and their functions, Marginal Distributions of Order Statistics, distribution of Range, Median, etc

Practical

Fitting of discrete distributions and test for goodness of fit; Fitting of continuous distributions and test for goodness of fit; Fitting of truncated distribution; Computation of simple, multiple and partial correlation coefficient, correlation ratio and intra-class correlation; Regression coefficients and regression equations; Fitting of Pearsonian curves; Analysis of association between attributes, categorical data and log-linear models.

References

Agresti A. 2002. *Categorical Data Analysis*. 2nd Ed. John Wiley.

Arnold BC, Balakrishnan N & Nagaraja HN. 1992. *A First Course inOrder Statistics*. John Wiley.

David HA & Nagaraja HN. 2003. *Order Statistics*. 3rd Ed. John Wiley.

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Johnson NL, Kotz S & Balakrishnan N. 2000. *Discrete Univariate Distributions*. John Wiley.

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STAT 562　　　　　　**STATISTICAL INFERENCE**　　　　　**2+1**

Objective

This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testing of hypothesis. They would also be given the concepts of nonparametric and sequential test procedures

Theory

UNIT I

Concepts of point estimation: MSE, unbiasedness, consistency, efficiency and sufficiency, statement of Neyman's Factorization theorem with applications, MVUE, Rao-Blackwell theorem, completeness, Lehmann-Scheffe theorem, Fisher information, Cramer-Rao lower bound and its applications.

UNIT II

Moments, minimum chi-square, least square and maximum likelihood methods of estimation and statements of their properties. Interval estimation-Confidence level, Confidence Interval for the parameters of Normal, Exponential, Binomial and Poisson distributions.

UNIT III

Fundamental notions of hypothesis testing-statistical hypothesis, statistical test, critical region, types of errors, test function, randomized tests, level of significance, power function, most powerful tests: Neyman-Pearson fundamental lemma, MLR families and UMP tests for one parameter exponential families. Concepts of Consistency, Unbiasedness and Invariance of tests, Likelihood Ratio tests, statement of asymptotic properties of LR tests with applications (including homogeneity of variances). Relation between confidence interval estimation and testing of hypothesis

UNIT IV

Notions of Sequential vs. Fixed Sample Size techniques, Wald's SPRT for testing simple null hypothesis vs. simple alternative, Termination property of SPRT, SPRT for Binomial, Poisson, Normal and Exponential distributions. Concepts of loss, risk and decision functions, admissible and optimal decision functions, estimation and testing viewed as decision problems, conjugate families, and Bayes and Minimax decision functions with applications to estimation with Quadratic loss.

UNIT V

Non-parametric tests: Sign test, Wilcoxon Signed Rank test, Runs test for randomness, Kolmogorov – Smirnov test for goodness of fit, Median test and Wilcoxon-Mann-Whitney U-test. Chi-square test for goodness of fit and test for independence of attributes. Kruskal –Wallis and Friedman's tests. Spearman's rank correlation and Kendall's Tau tests for independence

Practical

Methods of estimation - Maximum Likelihood, Minimum Chi-Square and Moments; Confidence Interval Estimation; MP and UMP tests; Large Sample tests; Examples on Non-parametric tests-Sign Test, Wilcoxon Signed Rank Test, Runs test for randomness, Kolmogorov – Smirnov test for goodness of fit, Median test and Wilcoxon-Mann-Whitney U-test, Chi-square test for goodness of fit and test for independence of attributes. Kruskal –Wallis and Friedman's tests. Spearman's rank correlation and Kendall's Tau tests for independence Probability Ratio Test.

References

Casela G & Berger RL. 2001. Statistical Inference. Duxbury Thompson Learning.

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Dudewicz EJ & Mishra SN. 1988. Modern Mathematical Statistics. John Wiley.

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STAT 563	MULTIVARIATE ANALYSIS	2+1

Objective

Most of the data sets in agricultural sciences are multivariate in nature. This course lays the foundation of Multivariate data analysis.

Theory

UNIT I

Concept of Random Vector, its expectation and Variance-Covariance matrix, Marginal and joint distributions, Conditional distributions and Independence of random vectors, Multinomial distribution, Multivariate Normal distribution, marginal and conditional distributions, Sample mean vector and its distribution. Maximum likelihood estimates of mean vector and dispersion matrix, Tests of hypothesis about mean vector.

UNIT II

Wishart distribution and its simple properties, Hotelling's T^2 and Mahalanobis D^2 statistics, Null distribution of Hotelling's T^2, Rao's U statistics and its distribution, Wilks criterion and statement of its properties, Concepts of discriminant analysis, computation of linear discriminant function, classification between k (e"2) multivariate normal populations based on LDF and Mahalanobis D^2

UNIT III

Principal Component Analysis, factor analysis (simple and multi factor models). Canonical Variables and Canonical Correlations, Cluster analysis, similarities and dissimilarities, Hierarchical clustering, Single and Complete linkage methods

UNIT IV

Path Analysis and computation of path coefficients, introduction to Multi Dimensional Scaling, some theoretical results, similarities, metric and non-metric scaling methods.

Practical

Fundamentals about MSEXCEL package for computing Matrix Inversion and Product of Matrices; Maximum Likelihood Estimates of Mean-Vector and Dispersion Matrix; Testing of hypothesis on Mean vectors of Multivariate Normal populations- Hotelling's T^2 test for Single and Two Samples; Cluster analysis, Discriminant function, Canonical Correlation, Principal Component Analysis, Factor analysis; Multivariate Analysis of Variance, Multi Dimensional Scaling.

References

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STAT 564 **DESIGN OF EXPERIMENTS** **2+1**

Objective

Design of Experiments provides the statistical tools to get maximum information from least amount of resources. This course is meant to expose the students to the basic principles of design of experiments. The students would also be provided with mathematical background of various basic designs

Theory

UNIT I

Elements of linear estimation, Gauss Markoff Theorem, relationship between BLUEs and linear zero-functions, Aitken's transformation, test of hypothesis, analysis of variance, partitioning of degrees of freedom.

UNIT II

Orthogonality, contrasts, mutually orthogonal contrasts, analysis of covariance; Basic principles of design of experiments, uniformity trials, size and shape of plots and blocks

UNIT III

Basic designs - completely randomized design, randomized complete block design and Latin square design; orthogonal Latin squares, mutually orthogonal Latin squares (MOLS), Youden square designs, Graeco Latin squares.

UNIT IV

Balanced incomplete block (BIB) designs – general properties and analysis without and with recovery of intra block information, construction of BIB designs. Partially balanced incomplete block designs with two associate classes - properties, analysis and construction, Lattice designs, alpha designs, cyclic designs, augmented designs, general analysis of block designs.

UNIT V

Factorial Experiments, Confounding in Symmetrical Factorial Experiments (2^n and 3^n series), partial and total confounding, fractional factorials, asymmetrical factorials

Designs for fitting response surface; Cross-over designs. Missing plot technique; Split plot and Strip plot design; Groups of experiments; Sampling in field experiments.

Practical

Determination of size and shape of plots and blocks from uniformity trials data; Analysis of data generated from completely randomized design, randomized complete block design; Latin square design, Youden square design; Analysis of data generated from a BIB design, lattice design, PBIB designs; 2^n, 3^n factorial experiments without and with confounding; Split and strip plot designs, repeated measurement design; Missing plot techniques, Analysis of covariance; Analysis of Groups of experiments, Analysis of clinical trial experiments, Sampling in field experiments

References

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Searle SR. 1971. *Linear Models*. John Wiley.

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Design Resources Server. *Indian Agricultural Statistics Research Institute (ICAR), New Delhi-110012, India*

STAT 565	SAMPLING TECHNIQUES	2+1

Objective

This course is meant to expose the students to the techniques of drawing representative samples from various populations and then preparing them on the mathematical formulations of estimating the population parameters based on the sample data. The students would also be exposed to the real life applications of sampling techniques and estimation of parameters.

Theory

UNIT I

Sample survey vs. complete survey, probability sampling, sample space, sampling design, sampling strategy; Inverse sampling; Determination of sample size; Confidence-interval; Simple random sampling, Estimation of population proportion, Stratified Random Sampling, Number of strata and optimum points of stratification.

UNIT II

Ratio and regression methods of estimation, Cluster sampling, Systematic sampling, Multistage sampling with equal probability, Separate and combined ratio estimator, Double sampling, Successive sampling –two occasions.

UNIT III

Non-sampling Errors– sources and classification, Non-response in surveys, Imputation methods, Randomized response techniques, Response errors –interpenetrating sub-sampling

UNIT IV

Sampling with varying probabilities with and without replacement, PPS sampling, Cumulative method and Lahiri's method of selection, Horvitz- Thompson estimator, Ordered and unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran, Inclusion probability proportional to size sampling, PPS systematic sampling, Multistage sampling with unequal probabilities, Self weighting design PPS sampling.

UNIT V

Unbiased ratio and regression type estimators, Multivariate ratio and regression type of estimators, Design effect, Bernoulli and Poisson sampling.

Practical

Determination of sample size and selection of sample; Simple random sampling, Inverse sampling, Stratified random sampling, Cluster sampling, systematic sampling; Ratio and regression methods of estimation; Double sampling, multi-stage sampling, Imputation methods; Randomized response techniques; Sampling with varying probabilities.

References

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STAT 566   STATISTICAL GENETICS   2+1

Objective

This course is meant to prepare the students in applications of statistics in quantitative genetics and breeding. The students would be exposed to the physical basis of inheritance, detection and estimation of linkage, estimation of genetic parameters and development of selection indices.

Theory

UNIT I

Physical basis of inheritance, Analysis of Segregation, detection and estimation of linkage for qualitative characters, Amount of information about linkage, combined estimation, disturbed segregation

UNIT II

Gene and genotypic frequencies, Random mating and Hardy –Weinberg law, Application and extension of the equilibrium law, Fisher's fundamental theorem of natural selection, Disequilibrium due to linkage for two pairs of genes, sex-linked genes, Theory of path coefficients

UNIT III

Concepts of inbreeding, regular system of inbreeding, Forces affecting gene frequency - selection, mutation and migration, equilibrium between forces in large populations, Random genetic drift, Effect of finite population size.

UNIT IV

Polygenic system for quantitative characters, concepts of breeding value and dominance deviation, Genetic variance and its partitioning, Effect of inbreeding on quantitative characters, Multiple allelism in continuous variation, Sex-linked genes, Maternal effects - estimation of their contribution.

UNIT V

Correlations between relatives, Heritability, Repeatability and Genetic correlation, Response due to selection, Selection index and its applications in plants and animals improvement programmes, Correlated response to selection.

UNIT VI

Restricted selection index, Variance component approach and linear regression approach for the analysis of GE interactions, Measurement of stability and adaptability for genotypes. Concepts of general and specific combining ability, Diallel and partial diallel crosses - construction and analysis.

Practical

Test for the single factor segregation ratios, homogeneity of the families with regard to single factor segregation; Detection and estimation of linkage parameter by different procedures; Estimation of genotypic and gene frequency from a given data. Hardy-Weinberg law; Estimation of changes in gene frequency due to systematic forces, inbreeding coefficient, genetic components of variation, heritability and repeatability coefficient, genetic correlation coefficient; Examination of effect of linkage, epistasis and inbreeding on mean and variance of metric traits; Mating designs; Construction of selection index including phenotypic index, restricted selection index, Correlated response to selection.

References

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STAT 567   REGRESSION ANALYSIS   1+1

Objective

This course is meant to prepare the students in linear and non-linear regression methods useful for statistical data analysis. They would also be provided a mathematical foundation behind these techniques and their applications in agricultural data.

Theory

UNIT I

Simple and Multiple linear regressions: Least squares fit, Properties and examples. Polynomial regression: Use of orthogonal polynomials.

UNIT II

Assumptions of regression; diagnostics and transformations; Examination of residuals – Studentised residuals, applications of residuals in detecting outliers, identification of influential observations, Lack of fit, Pure error, Testing homoscedasticity and normality of errors, Durbin-Watson test. Use of R^2 for examining goodness of fit

UNIT III

Concept of Least Median of Squares and its applications; Concept of Multicollinearity, Analysis of Multiple Regression Models, estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation.

UNIT IV

Weighted least squares method: Properties, and examples. Box-Cox Family of transformations. Use of dummy variables, Selection of variables: Forward selection, Backward Elimination, Stepwise and Stagewise Regressions

UNIT V

Introduction to Non-Linear Models, Non-Linear estimation: Least Squares for Non-Linear Models.

Practical

Multiple regression fitting with three and four independent variables; Estimation of residuals, their applications in outlier detection, distribution of residuals; Test of homoscedasticity, and normality, Box-Cox transformation; Restricted estimation of parameters in the model, hypothesis testing, Step wise regression analysis; Least median of squares norm, Orthogonal polynomial fitting.

References

Barnett V & Lewis T. 1984. *Outliers in Statistical Data.* John Wiley.

Belsley DA, Kuh E & Welsch RE. 2004. *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity.* John Wiley.

Chatterjee S, Hadi A & Price B. 1999. *Regression Analysis by Examples.* John Wiley.

Draper NR & Smith H. 1998. *Applied Regression Analysis.* 3rd Ed. John Wiley.

McCullagh P & Nelder JA. 1999. *Generalized Linear Models.* 2nd Ed. Chapman & Hall.

Montgomery DC, Peck EA & Vining GG. 2003. *Introduction to Linear Regression Analysis.* 3rd Ed. John Wiley.

Rao CR. 1973. *Linear Statistical Inference and its Applications.* 2nd Ed. John Wiley.

STAT 568   STATISTICAL COMPUTING   1+1

Objective

This course is meant for exposing the students in the concepts of computational techniques. Various statistical packages would be used for teaching the concepts of computational techniques

Theory

UNIT I

Introduction to statistical packages and computing: data types and structures, pattern recognition, classification, association rules, graphical methods. Data analysis principles and practice

UNIT II

ANOVA, Regression and Categorical data methods, Model formulation, fitting, diagnostics and validation; Matrix computations in linear models, Analysis of discrete data

UNIT III

Numerical linear algebra, numerical optimization, graphical techniques, numerical approximations, numerical integration and Monte Carlo methods

UNIT IV

Spatial statistics: spatial sampling; hierarchical modeling, Analysis of cohort studies, case-control studies and randomized clinical trials, techniques in the analysis of survival data and longitudinal studies, Approaches to handling missing data, and meta-analysis.

Practical

Data management, Graphical representation of data, Descriptive statistics; General linear models ~ fitting and analysis of residuals, outlier detection; Categorical data analysis, analysis of discrete data, analysis of binary data; Numerical algorithms; Spatial modeling, cohort studies; Clinical trials, analysis of survival data; Handling missing data.

References

Agresti A. 2002. Categorical Data Analysis. 2nd Ed. John Wiley.

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TIME SERIES ANALYSIS   1+1

Objective

This course is meant to teach the students the concepts involved in time series data. They would also be exposed to components of time series, stationary models and forecasting/ projecting the future scenarios based on time series data.

Theory

UNIT I

Components of a time-series, Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis

UNIT II

Linear stationary models: Autoregressive, Moving Average and Mixed Processes, Linear Non-Stationary Models: Autoregressive Integrated Moving Average Processes.

UNIT III

Forecasting: Minimum Mean Square forecasts and their properties, calculating and updating forecasts

UNIT IV

Model identification: Objectives, Techniques, and Initial estimates. Model estimation: Likelihood function, Sum of squares function, Least squares estimates, Seasonal Models, Intervention Analysis Models and Outlier Detection.

Practical

Time series analysis, autocorrelations, Correlogram and Periodogram; Linear Stationary Model, Linear Non-stationary model; Model identification and model estimation; Intervention analysis and outliers detection

References

Box GEP, Jenkins GM & Reinsel GC. 2007. *Time Series Analysis: Forecasting and Control.* 3rd Ed. Pearson Edu.

Brockwell PJ & Davis RA. 2002. *Introduction to Time Series and Forecasting.* 2nd Ed. Springer.

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Judge GG, Hill RC, Griffiths WE, Lutkepohl H & Lee TC. 1988. *Introduction to the Theory and Practice of Econometrics.* 2nd Ed. John Wiley.

Montgomery DC & Johnson LA. 1976. *Forecasting and Time Series Analysis.* McGraw Hill.

Shumway RH & Stoffer DS. 2006. *Time Series Analysis and its Applications: With R Examples.* 2nd Ed. Springer.

Objective

This course provides exposure to the specialized statistical techniques such as probability models, life tables, insurance and annuities along with the real data applications.

Theory

UNIT I

Insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality

UNIT Ii

Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

UNIT III

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions, evaluation for special mortality laws, multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

UNIT IV

Distribution of aggregate claims, compound Poisson distribution and its applications

UNIT V

Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

UNIT VI

Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions.

UNIT VII

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

UNIT VIII

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

UNIT IX

Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

Practical

Insurance and utility theory- Developing models for individual claims and their sums and survival function; Developing Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions; Developing Single decrement tables, central rates of multiple decrement, net single premiums; Applications Compound Poisson distribution in distribution of aggregate claims, Examples on computation of compound interest, nominal and effective rates of interest and discount, force of interest and discount, accumulation factor and continuous compounding, Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, Computation of Net premiums- Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits.

References

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Rotar VI. 2006. *Actuarial Models. The Mathematics of Insurance*, Chapman & Hall/CRC

Spurgeon ET. 1972. *Life Contingencies*. Cambridge Univ. Press

| STAT 571 | **BIOINFORMATICS** | 1+1 |

Objective

Bioinformatics is a new emerging specialized field. This course is an integration of Statistics, Computer applications and Biology, developed specifically for understanding bioinformatics principles. .

Theory

UNIT I

Basic Biology: Cell, genes, gene structures, gene expression and regulation, Molecular tools, nucleotides, nucleic acids, markers, proteins and enzymes, bioenergetics, single nucleotide polymorphism, expressed sequence tag. Structural and functional genomics: Organization and structure of genomes, genome mapping, assembling of physical maps, strategies and techniques for genome sequencing and analysis.

UNIT II

Computing techniques: OS and Programming Languages – *Linux, perl, bioperl, cgi, MySQL, phpMyAdmin*; Coding for browsing biological databases on web; parsing & annotation of genomic sequences; Database designing; Computer networks – Internet, World wide web, Web browsers – EMBnet, NCBI; Databases on public domain pertaining to Nucleic acid sequences, protein sequences, SNPs, etc.; Searching sequence databases, Structural databases.

UNIT III

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Re-sampling techniques – Bootstrapping and Jack-knifing; Hidden Markov Models; Bayesian estimation and Gibbs sampling;

UNIT IV

Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis, Approaches to EST analysis; Pair-wise alignment techniques: Comparing two sequences, PAM and BLOSUM, Global alignment (The Needleman and Wunsch algorithm), Local Alignment (The Smith-Waterman algorithm), Dynamic programming, Pair wise database searching; Sequence analysis– BLAST and other related tools, Multiple alignment and database search using motif models, ClustalW, Phylogeny; Databases on SNPs; EM algorithm and other methods to discover common motifs in biosequences; Gene prediction based on Neural Networks, Genetic algorithms, Hidden Markov models. Computational analysis of protein sequence, structure and function; Design and Analysis of microarray experiments

Practical

Practical examples on computing techniques using Packages, Applications of Statistical techniques like MANOVA, Cluster Analysis, Multi Dimensional Scaling and Multiple Regression, Bootstrapping and Jack-knifing; DNA Sequence Analysis; Gene prediction based on Neural Networks, Genetic algorithms, Hidden Markov models. Computational analysis of protein sequence, structure and function; Design and Analysis of microarray experiments

References

Baldi P & Brunak S. 2001. *Bioinformatics: The Machine Learning Approach.* 2nd Ed. (Adaptive Computation and Machine Learning). MIT Press.

Baxevanis AD & Francis BF. (Eds.). 2004. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins.* John Wiley.

Bergeron BP. 2002. *Bioinformatics Computing.* Prentice Hall.

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Jones NC & Pevzner PA. 2004. *An Introduction to Bioinformatics Algorithms.* MIT Press.

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Krane DE & Raymer ML. 2002. *Fundamental Concepts of Bio-informatics*. Benjamin/Cummings.

Krawetz SA & Womble DD. 2003. *Introduction to Bioinformatics: A Theoretical and Practical Approach*. Humana Press.

Lesk AM. 2002. *Introduction to Bio-informatics*. Oxford Univ. Press.

Percus JK. 2001. *Mathematics of Genome Analysis*. Cambridge Univ. Press.

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Tisdall JD. 2003. *Beginning Perl for Bioinformatics*. O'Reilly & Associates.

Wang JTL, Zaki MJ, Toivonen HTT & Shasha D. 2004. *Data Mining in Bioinformatics*. Springer.

Wu CH & McLarty JW. 2000. *Neural Networks and Genome Informatics*. Elsevier.

Wunschiers R. 2004. *Computational Biology Unix/Linux, Data Processing and Programming*. Springer.

STAT 572 **ECONOMETRICS** **1+1**

Objective

This course is meant for training the students in econometric methods and their applications in agriculture. This course would enable the students in understanding the economic phenomena through statistical tools and economics principles

Theory

UNIT I

Representation of Economic phenomenon, relationship among economic variables, linear and non linear economic models, single equation general linear regression model, basic assumptions, Ordinary least squares method of estimation for simple and multiple regression models; summary statistics correlation matrix, co-efficient of multiple determination, standard errors of estimated parameters, tests of significance and confidence interval estimation, BLUE, properties of Least Squares estimates. Chow test, test of improvement of fit through additional regressors. Maximum Likelihood Estimation

UNIT II

Heteroscedasticity, Auto-correlation, Durbin Watson test, Multicollinearity. Stochastic regressors, Errors in variables, Use of instrumental variables in regression analysis, Dummy Variables, Distributed Lag models: Koyck's Geometric Lag scheme, Adaptive Expectation and Partial Adjustment Mode, Rational Expectation Models and test for rationality.

UNIT III

Simultaneous Equation Model: Basic rationale, Consequences of simultaneous relations, Identification problem, Conditions of Identification, Indirect Least Squares, Two-stage least squares, K-class estimators, Limited Information and Full Information Maximum Likelihood Methods, Three stage least squares, Generalized least squares, Recursive models, SURE Models, Mixed Estimation Methods, use of instrumental variables, pooling of cross-section and time series data, Principal Component Methods.

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UNIT IV

Problem and Construction of index numbers and their tests; fixed and chain based index numbers; Construction of cost of living index number.

UNIT V

Demand analysis – Demand and Supply Curves; Determination of demand curves from market data. Engel's Law and the Engel's Curves, Income distribution and method of its estimation, Pareto's Curve, Income inequality measures.

Practical

Fitting of Single equation general linear regression model and testing of parameters; Fitting of Multiple Regression Models with two Independent variables, Computation of Correlation Matrix, Overall testing of regression with ANOVA and testing of parameters; Auto-correlation, Durbin Watson test, Testing the Multicollinearity in Multiple Regression; Dummy Variables, Distributed Lag models; Simultaneous Equation Model- Examining the identification of the models with examples; Application of Indirect Least Squares method of estimation; Applications of Two-stage least squares; Three stage least squares; Application of Principal Components Method and Construction of index numbers and their tests; fixed and chain based index numbers; Construction of cost of living index number.

References

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Judge GC, Hill RC, Griffiths WE, Lutkepohl H & Lee TC. 1988. *Introduction to the Theory and Practice of Econometrics*. 2nd Ed. John Wiley.

Kmenta J. 1986. *Elements of Econometrics*. 2nd Ed. University of Michigan Press.

Koop G. 2007. *Introduction to Econometrics*. John Wiley.

Maddala GS. 2001. *Introduction to Econometrics*. 3rd Ed. John Wiley.

Pindyck RS & Rubinfeld DL. 1998. *Econometric Models and Economic Forecasts*. 4th Ed. McGraw Hill.

Verbeek M. 2008. *A Guide to Modern Econometrics*. 3rd Ed. John Wiley.

STAT 573 **STATISTICAL QUALITY CONTROL** **1+1**

Objective

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agribusiness and agro-processing industries. This course would enable the students to have an idea about the statistical techniques used in quality control.

Theory

UNIT I

Introduction to Statistical Quality Control; Control Charts for Variables–Mean, Standard Deviation and Range charts; Statistical basis; rational subgroups

UNIT II

Control charts for attributes- 'np', 'p' and 'c' charts.

UNIT III

Fundamental concepts of acceptance sampling plans, single, double and sequential sampling plans for attributes inspection

UNIT IV

Sampling inspection tables for selection of single and double sampling plans.

Practical

Developing Control Charts for Variables: X-Bar and R Charts; Control Charts for Attributes: np, p and c charts; Acceptance Sampling Plans: developing OC Curves, AOQ and ASN Curves for a given sampling situation using Binomial and Poisson approximation approach.

References

Cowden DJ. 1957. *Statistical Methods in Quality Control*. Prentice Hall of India.

Dodge HF & Romig HG. 1959. *Sampling Inspection Tables*. John Wiley.

Duncan A.J. 1986. *Quality Control and Industrial Statistics*. 5th Ed. Irwin Book Co.

Grant EL & Leavenworth RS. 1996. *Statistical Quality Control*. 7th Ed. McGraw Hill.

Montgomery DC. 2005. *Introduction to Statistical Quality Control*. 5th Ed. John Wiley.

Wetherhil G.B. 1977. *Sampling Inspection and Quality Control*. Halsted Press.

| STAT 574 | OPTIMIZATION TECHNIQUES | 1+1 |

Objective

This course is developed to provide exposure to the optimization techniques such as linear programming, non-linear programming and multiple objective programming with practical applications.

Theory

UNIT I

Classical Optimization Techniques: Necessary Conditions for an Extremum, Constrained Optimization: Lagrange Multipliers, Statistical Applications, Optimization and Inequalities, Classical Inequalities, like Cauchy-Schwarz Inequality, Jensen Inequality and Markov Inequality.

UNIT II

Numerical Methods of Optimization: Numerical Evaluation of Roots of Equations, Direct Search Methods, Sequential Search Methods – Fibonacci Search Method. Random Search Method – Method of Hooke and Jeeves, Simplex Search Method, Gradient Methods, like Newton's Method, and Method of Steepest Ascent, Nonlinear Regression and Other Statistical Algorithms, like Expectation – Maximization Algorithm.

UNIT III

Linear programming Techniques – Simplex Method, Karmarkar's Algorithm, Duality and Sensitivity Analysis, Zero-sum Two-person Finite Games and Linear Programming, Integer Programming, Statistical Applications.

UNIT IV

Nonlinear Programming and its Examples, Kuhn-Tucker Conditions, Quadratic Programming, Convex Programming, Basics of Stochastic Programming, Applications, Elements of Multiple Objective Programming, Dynamic Programming, Optimal Control Theory–Pontryagin's Maximum Principle, Time-Optimal Control Problems.

Practical

Problems based on classical optimization techniques; Problems based on optimization techniques with constraints; Minimization problems using numerical methods; Linear programming (LP) problems through graphical method; LP problem by Simplex method; LP problem using Simplex method (Two-phase method); LP problem using primal and dual method; Sensitivity analysis for LP problem; LP problem using Karmarkar's method; Problems based on Quadratic programming; Problems based on Integer programming; Problems based on Dynamic programming; Problems based on Pontryagin's Maximum Principle.

References

Rao SS. 2007. *Engineering Optimization: Theory and Practice*. 3rd Ed. New Age.

Rustagi JS. 1994. *Optimization Techniques in Statistics*. Academic Press.

Taha HA. 2007. *Operations Research: Introduction with CD*. 8th Ed. Pearson Edu.

Zeleny M. 1974. *Linear Multiobjective Programming*. Springer.

STAT 575   **DEMOGRAPHY**   **1+1**

Objective

This course is meant for training the students in measures of demographic indices, estimation procedures of demographic parameters. Students would also be exposed to population projection techniques and principles involved in bioassays.

Theory

UNIT I

Introduction to vital statistics, crude and standard mortality and morbidity rates, Estimation of mortality, Measures of fertility and mortality, period and cohort measures.

UNIT II

Life tables and their applications, methods of construction of abridged life tables, Increment-Decrement Life Tables

UNIT III

Stationary and stable populations, Migration and immigration, Application of stable population theory to estimate vital rates, migration and its estimation, Demographic relations in Non-stable populations, Measurement of population growth, Lotka's model(deterministic) and intrinsic rate of growth, Measures of mortality and morbidity, Period and cohort measures

UNIT IV

Principle of biological assays, parallel line and slope ratio assays, choice of doses and efficiency in assays quantal responses, probit and logit transformations, epidemiological models.

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Practical

Estimation of mortality : crude and standard mortality and morbidity rates; Measures of fertility and mortality, period and cohort measures; Construction of Life tables abridged Life Tables and Increment-Decrement Life tables; Estimation of vital rates and Migration; Measurement of population growth deterministic Model; Estimation of intrinsic rate of growth, mortality and morbidity by Period Method; Measures of mortality and morbidity by cohort measures, Estimation of Parallel line and slope ratio assays, Quantal responses by Probit Transformations, Quantal responses by Logit Transformations and Epidemiological models.

References

Cox DR. 1957. Demography. Cambridge Univ. Press.

Finney DJ. 1981. Statistical Methods in Biological Assays. Charles Griffin.

Fleiss JL. 1981. Statistical Methods for Rates and Proportions. John Wiley.

Lawless JF. 1982. Statistical Models and Methods for Lifetime Data. John Wiley.

MacMahon B & Pugh TF. 1970. Epidemiology- Principles and Methods. Little Brown, Boston.

Mann NR, Schafer RE & Singpurwalla ND. 1974. Methods for Statistical Analysis of Reliability and Life Data. John Wiley.

Newell C. 1988. Methods and Models in Demography. Guilford Publ.

Preston S, Heuveline P & Guillot M. 2001. Demography: Measuring and Modeling Population Processes. Blackwell Publ.

Rowland DT. 2004. Demographic Methods and Concepts. Oxford Press.

Siegel JS & Swanson DA. 2004. The Methods and Material of Demography. 2nd Ed. Elsevier.

Woolson FR. 1987. Statistical Methods for the Analysis of Biomedical Data. John Wiley.

| STAT 576 | STATISTICAL METHODS FOR LIFE SCIENCES | 1+1 |

Objective

Statistical methods applicable to analysis of data in Public Health, Clinical and Biological studies are included in this course. The students will be benefited with the applications of statistical methods in this area.

Theory

UNIT I

Proportions and counts, contingency tables, logistic regression models, Poisson regression and log-linear models, models for polytomous data and generalized linear models.

UNIT II

Computing techniques, numerical methods, simulation and general implementation of bio-statistical analysis techniques with emphasis on data applications, Analysis of survival time data using parametric and nonparametric models, hypothesis testing, and methods for analyzing censored (partially observed) data with covariates. Topics include marginal estimation of a survival function, estimation of a generalized multivariate linear regression model (allowing missing covariates and/or outcomes).

UNIT III

Proportional Hazard model: Methods of estimation, estimation of survival functions, time-dependent covariates, estimation of a multiplicative intensity model (such as Cox proportional hazards model) and estimation of causal parameters assuming marginal structural models.

UNIT IV

General theory for developing locally efficient estimators of the parameters of interest in censored data models, Rank tests with censored data, Computing techniques, numerical methods, simulation and general implementation of bio-statistical analysis techniques with emphasis on data Applications

UNIT V

Newton, scoring, and EM algorithms for maximization; smoothing methods; bootstrapping; trees and neural networks; clustering; isotonic regression; Markov chain Monte Carlo methods

Practical

Fitting of Logistic Regression models, Poisson regression and log-linear models, models for polytomous data and generalized linear models; Analysis of survival time data using parametric and nonparametric models, fitting of proportional hazard model; Newton, scoring, and EM algorithms for maximization; smoothing methods; bootstrapping; trees and neural networks; clustering; isotonic regression.

References

Biswas S. 1995. *Applied Stochastic Processes. A Biostatistical and Population Oriented Approach.* Wiley Eastern Ltd.

Collett D. 2003. *Modeling Survival Data in Medical Research.* Chapman & Hall.

Cox DR & Oakes D. 1984. *Analysis of Survival Data.* Chapman & Hall.

Hosmer DW Jr. & Lemeshow S. 1999. *Applied Survival Analysis: Regression Modeling or Time to Event.* John Wiley.

Klein JP & Moeschberger ML. 2003. *Survival Analysis: Techniques for Censored and Truncated Data.* Springer.

Kleinbaum DG & Klein M 2005. *Survival Analysis. A Self Learning Text.* Springer.

Kleinbaum DG & Klein M. 2005. *Logistic Regression.* 2nd Ed. Springer.

Lee ET. 1992. *Statistical Methods for Survival Data Analysis.* John Wiley.

Miller RG. 1981. *Survival Analysis.* John Wiley.

Therneau TM & Grambsch PM. 2000. *Modeling Survival Data: Extending the Cox Model.* Springer.

| STAT 577 | STATISTICAL ECOLOGY | 1+1 |

Objective

This course is developed to provide exposure to statistical methods applicable to collection and analysis of ecological data

Theory

UNIT I

Ecological data, Ecological sampling; spatial pattern analysis: Distribution methods, Quadrant-variance methods, Distance methods.

UNIT II

Species-abundance relations: Distribution models, Diversity indices; Species affinity: Niche-overlap indices, inter-specific association and inter-specific co-variation.

UNIT III

Community classification: Resemblance functions, Association analysis, Cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondence analysis, Nonlinear ordination.

UNIT IV

Community interpretation: Classification Interpretation and Ordination Interpretation.

Practical

Examples on Ecological sampling; spatial pattern analysis; Quadrant-variance methods; developing Diversity indices; Species affinity: Niche-overlap indices; Developing resemblance functions, association analysis, cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondence analysis, Nonlinear ordination.

References

Pielou EC. 1970. *An introduction to Mathematical Ecology.* John Wiley.

Reynolds JF & Ludwig JA. 1988. *Statistical Ecology: A Primer on Methods and Computing.* John Wiley.

Young LJ, Young JH & Young J. 1998. *Statistical Ecology: A Population Perspective.* Kluwer.

STAT 551   **MATHEMATICAL METHODS – I**   **2+1**

Objective

The course lays the foundation for all the courses of statistics by providing exposure to the basic mathematical methods such as Calculus, Real analysis and Numerical analysis.

Theory

UNIT I

Real Analysis: Convergence and divergence of infinite series, use of comparison tests - D'Alembert's Ratio - test, Cauchy's nth root test, Raabe's test, Kummer's test, Gauss test. Absolute and Conditional Convergence, Riemann Integration, concept of Lebesgue integration, power series, Fourier, Laplace and Laplace -Steiltjes' transformation, multiple integrals.

UNIT II

Calculus: Limit and continuity, differentiation of functions, successive differentiation, partial differentiation, mean value theorems, Taylor and Maclaurin's series, Application of

Derivatives, L'Hospital's rule. Integration of rational, irrational and trigonometric functions, Application of integration

UNIT III

Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient.

UNIT IV

Numerical Analysis: Simple interpolation, divided differences, Numerical differentiation and integration.

Practical

Examples on Convergence and divergence of infinite series; D'Alembert's Ratio test and Cauchy's nth root test; Raabe's test, Kummer's test and Gauss test; Examples on Power series, Fourier, Laplace and Laplace -Steiltjes' transformation; Examples on Successive differentiation and Partial differentiation, Mean value theorems; Application of Derivatives, L'Hospital's rule; Integration of rational, irrational and trigonometric functions; Examples on Applications of integration, Differential equations of first order, Linear differential equations of higher order with constant coefficient, Examples on Simple interpolation; Examples on Numerical differentiation and integration

References

Bartle RG. 1976. *Elements of Real Analysis*. John Wiley

Chatterjee SK. 1970. *Mathematical Analysis*, Oxford & IBH

Gibson GA. 1954. *Advanced Calculus*, Macmillan

Henrice P. 1964. *Elements of Numerical Analysis*, John Wiley

Hildebrand FB. 1956. *Introduction to Numerical Analysis*. Tata McGraw Hill

Priestley HA. 1985. *Complex Analysis*. Clarenton Press.

Rudin W. 1985. *Principles of Mathematical Analysis*, McGraw Hill

Sauer T. 2006. *Numerical Analysis with CD-Rom*, Addison Wesley

Scarborough JB. 1976. *Numerical Mathematical Analysis*. Oxford & IBH.

Stewart J. 2007. *Calculus*. Thompson.

Thomas GB Jr. & Finney RL. 1996. Calculus. 9th Ed. Pearson Edu.

| STAT 552 | MATHEMATICAL METHODS – II | 1+1 |

Objective

This is another supporting course which is developed to understand the advanced mathematical methods that are applied in various courses of statistics. It provides exposure to advances in Linear Algebra and Matrix theory.

Theory

UNIT I

Linear Algebra: Group, ring, field and vector spaces, Sub-spaces, basis, Gram Schmidt's orthogonalization, Galois field - Fermat's theorem and primitive elements, linear transformations. Graph theory: Concepts and applications

UNIT II

Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form, Determinants, rank and inverse of matrices, Special matrices – idempotent, symmetric, orthogonal. Eigen Values and Eigen Vectors, Spectral decomposition of matrices

UNIT III

Unitary, Similar, Hadamard, Circulant, Helmert's matrices. Kronecker and Hadamard product of matrices, Kronecker Sum of Matrices, Sub-Matrices and partitioned matrices, Permutation matrices, full rank factorization, Grammian root of a symmetric matrix, Solutions of linear equations, Equations having many solutions.

UNIT IV

Generalized Inverses: Moore-Penrose inverse, Applications of g-inverse, Spectral Decomposition of Matrices, Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of matrices, Quadratic forms

Practical

Examples on Gram Schmidt's orthogonalization, Graph theory; Echelon form, Determinants, rank and inverse of matrices; Special matrices – idempotent, symmetric and orthogonal; Eigen Values and Eigen Vectors, Spectral decomposition of matrices; Unitary, Similar, Hadamard, Circulant, Helmert's matrices. Kronecker and Hadamard product of matrices, Kronecker Sum of Matrices, Sub-Matrices and partitioned matrices, Permutation matrices, full rank factorization, Grammian root of a symmetric matrix, Solutions of linear equations, Equations having many solutions; Computation of Moore-Penrose inverse, g-inverse; Differentiation and integration of matrices, Quadratic forms.

References

Aschbacher M. 2000. *Finite Group Theory*. Cambridge University Press.

Deo N. 1984. *Graph Theory with Application to Engineering and Computer Science*. Prentice Hall of India.

Gentle JE. 2007. *Matrix Algebra: Theory, Computations and Applications in Statistics*. Springer.

Graybill FE.1961. *Introduction to Matrices with Applications in Statistics*. Wadsworth Publ.

Hadley G. 1969. *Linear Algebra*. Addison Wesley.

Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.

Rao CR. 1965. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Robinson DJS. 1991. *A Course in Linear Algebra with Applications*. World Scientific.

Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.

Seber GAF. 2008. *A Matrix Handbook for Statisticians*. John Wiley.

COMPULSORY NON-CREDIT COURSES
(Compulsory for Master's programme in all disciplines; Optional for Ph.D. scholars)

Course Contents

PGS 501   **LIBRARY AND INFORMATION SERVICES**   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; eresources access methods.

PGS 502   **TECHNICAL WRITING AND COMMUNICATIONS SKILLS**   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

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.

Collins' Cobuild English Dictionary. 1995. Harper Collins.

Gordon HM & Walter JA. 1970. *Technical Writing.* 3rd Ed. Holt, Rinehart & Winston.

Hornby AS. 2000. *Comp. Oxford Advanced Learner's Dictionary of Current English.* 6th Ed. Oxford University Press.

James HS. 1994. *Handbook for Technical Writing.* NTC Business Books.

Joseph G. 2000. *MLA Handbook for Writers of Research Papers.* 5th Ed. Affiliated East-West Press.

Mohan K. 2005. *Speaking English Effectively.* MacMillan India.

Richard WS. 1969. *Technical Writing.* Barnes & Noble.

Robert C. (Ed.). 2005. *Spoken English: Flourish Your Language.* Abhishek.

Sethi J & Dhamija PV. 2004. *Course in Phonetics and Spoken English.* 2nd Ed. Prentice Hall of India.

Wren PC & Martin H. 2006. *High School English Grammar and Composition.* S. Chand & Co.

PGS 503 (e-Course)	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	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.

Ganguli P. 2001. *Intellectual Property Rights: Unleashing Knowledge Economy*. McGraw-Hill.

Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.

Ministry of Agriculture, Government of India. 2004. *State of Indian Farmer*. Vol. V. *Technology Generation and IPR Issues*. Academic Foundation.

Rothschild M & Scott N. (Ed.). 2003. *Intellectual Property Rights in Animal Breeding and Genetics*. CABI.

Saha R. (Ed.). 2006. *Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies*. Daya Publ. House.

The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000;

Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS 504   BASIC CONCEPTS IN LABORATORY TECHNIQUES   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.

PGS 505 — AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES

PGS 505
(e-Course)

**AGRICULTURAL RESEARCH, RESEARCH ETHICS
AND RURAL DEVELOPMENT PROGRAMMES**

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.

| PGS 506 | DISASTER MANAGEMENT | 1+0 |

PGS 506
(e-Course)

DISASTER MANAGEMENT

1+0

Objectives

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.

Sharma VK. 2001. *Disaster Management*. National Centre for Disaster Management, India.