Department of Plant Breeding and Genetics

Degree programme Ph.D. Genetics and Plant Breeding

Courses offer

Group		Number	Title of Course	Credit
Major	1.	GP 602	Advances biometrical and quantitative genetics	3 (2+1)
	2.	GP 603	Genomics in plant breeding	3 (2+1)
	3.	GP 604	Molecular and chromosomal manipulations for crop breeding	2 (2+0)
	4.	GP 605	Advances in Plant Breeding Systems	2 (2+0)
	5.	GP 607	Breeding Designer Crops	3 (2+1)
	6.	GP 608	Advances in Breeding of Major Field Crops	3 (3+0)
	Total			**16(13+3)**
Seminar	1	GP 691	Doctoral Seminar I	**2 (0+2)**
Research	1	GP 599	Doctoral Research	**45 (0+45)**
Minor	1.	PP 605	Climate change and crop growth	2 (2+0)
	2.	SOILS 602	Advances in Soil fertility	2 (2+0)
	3.	AGRON 606	Advances in Weed management	2 (2+0)
	4.	PP 608	Advances in Seed Physiology	3 (2+1)
	Total			**9(8+1)**
Supporting	1.	STAT 521	Applied regression analysis	3 (2+1)
	2.	STAT 531	Data analysis using Statistical package	3 (2+1)
	Total			**6(4+2)**
Non-Credit Compulsory Course	1.	PGS-501	Library & Information Services	1(0+1)
	2.	PGS-504	Basic Concept in Laboratory Techniques	1(0+1)
	3.	PGS-505	Agril. Research, Res. Ethics & Rural Development Programme (e-course)	1(1+0)
	4	PGS-506	Disaster Management	1(1+0)
	5	PGS-502	Technical writing and communication skill	1(0+1)
	6	PGS-503	Intellectual properties and its management	1(1+0)
	7	HVE	Human values and professional ethics	2(1+1)
	Total			**8(4+4)**
Grand total				**86(29+57)**

Note: The non credit courses PGS 501, 502, 503, 504, 505, 506 (six courses) and credit course Human Value & Professional Ethics (HVE) is compulsory for those students who have not taken these courses in their M.Sc. (Ag.) degree programme.

Department of Plant Breeding and Genetics

Programme Ph.D. Genetics and Plant Breeding

Minimum credit requirements

Subject	Master
Major	16
Minor	09
Supporting	06
Seminar	02
Thesis research	45
Total	78

Department of Plant Breeding and Genetics

Programme Ph.D. Genetics and Plant Breeding

Semesters wise distribution of courses

Course	Course Title	Code	Credits
Semester-I			
Major	Advances biometrical and quantitative genetics	GP 602	3 (2+1)
	Genomics in plant breeding	GP 603	3 (2+1)
	Molecular and chromosomal manipulations for crop breeding	GP 604	2 (2+0)
Minor	Climate change and crop growth	PP 605	2 (2+0)
	Advances in Soil fertility	SOILS 602	2 (2+0)
Supporting	Applied regression analysis	STAT 521	3 (2+1)
Compulsory NC	Library and information services	PGS 501	1 (0+1)
	Basic concepts in laboratory techniques	PGS 504	1 (0+1)
	Intellectual property and its management in Agriculture	PGS- 503	1 (0+1)
Semester-II			
Major	Advances in Plant Breeding Systems	GP 605	2 (2+0)
	Breeding Designer Crops	GP 607	3 (2+1)
	Advances in Breeding of Major Field Crops	GP 608	3 (3+0)
Minor	Advances in Weed management	AGRON 606	2 (2+0)
	Advances in Seed Physiology	PP 608	3 (2+1)
Supporting	Data analysis using Statistical package	AST 531	3 (2+1)
Compulsory NC	Agricultural research, research ethics and rural development programmes	PGS 505	1 (0+1)
	Disaster management	PGS506	1 (0+1)
	Technical writing and communication skills	PGS- 502	1 (0+1)
Semester-III			
	Written Comprehensive Examination	-	
	Seminar	GP 691	2 (0+2)
	Master's Research	GP 699	20 (0+20)
Semester-IV			
	Master's Research	GP 599	25(0+25)

GP 602 Advanced Biometrical and Quantitative Genetics 2+1

Objective: To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory:

UNIT I Basic principles of Biometrical Genetics; Selection of parents; Advanced biometrical models for combining ability analysis; Simultaneous selection models; Use of Multiple regression analysis in selection of genotypes; Designs and Systems; Selection of stable genotypes.

UNIT II Models in stability analysis - Pattern analysis - Additive Main Effect and Multiplicative Interaction (AMMI) analysis and other related models; Principal Component Analysis.

UNIT III Additive and multiplicative model - Shifted multiplicative model; Analysis and selection of genotypes; Methods and steps to select the best model - Biplots and mapping genotypes.

UNIT IV Genetic architecture of quantitative traits; Conventional analyses to detect gene actions - Partitioning of phenotypic/genotypic variance – Construction of saturated linkage maps, concept of framework map development; QTL mapping-Strategies for QTL mapping - desired populations, statistical methods; Marker Assisted Selection (MAS) - Approaches to apply MAS in Plant breeding – selection based on markers - simultaneous selection based on marker and phenotype - Factors influencing MAS; Heritability of the trait, proportion of genetic variance, linkage disequilibrium between markers and traits and selection methods.

Practical:

Working out efficiency of selection methods in different populations and interpretation - Biparental mating – use of softwares in analysis and result interpretation - Triallel analysis– use of softwares in analysis and result interpretation - Quadriallel analysis – use of softwares in analysis and result interpretation - Triple Test Cross (TTC) – use of softwares in analysis and result interpretation - Advanced biometrical models for combining ability analysis - Selection of stable genotypes using stability analysis; Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model - Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes. Construction of linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies.

Suggested Readings:

Bos I & P Caligari. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
Falconer DS & Mackay J. 1996. *Introduction to Quantitative Genetics*. Longman.
Mather K & Jinks L. 1983. *Introduction to Biometrical Genetics*. Chapman & Hall. Nadarajan N & Gunasekaran M. 2005. *Quantitative Genetics and Biometrical Techniques in Plant Breeding*. Kalyani.
Singh P & Narayanan SS. 1993. *Biometrical Techniques in Plant Breeding*. Kalyani.
Singh RK & Choudhary BD. 1987. *Biometrical Methods in Quantitative Genetics*. Kalyani.
Weir DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.
Wricke G & Weber WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.

GP 603 Genomics in Plant Breeding 2+1

Objective: To impart practical skills in advanced molecular techniques in genome mapping structural/functional genomics and development of transgenic crops.

Theory:

UNIT I Introduction to the plant genome- Plant nuclear genomes and their molecular description - The chloroplast and the mitochondrial genomes in plants – Genome size and complexity.

UNIT II Establishment of plant genome mapping projects - Genome mapping and use of molecular markers in plant breeding; Strategies for mapping genes of agronomic traits in plants- Approaches for mapping quantitative trait loci; Map based cloning of plant genes.

UNIT III Regulation of Plant gene expression - Functional genomics – Expression Analysis using Microarrays – Transposon tagging and Insertional mutagenesis- methods and significance- Diversity Array Technology.

UNIT IV Genome sequencing in plants–Principles and Techniques; Applications of sequence information in plant genome analyses; Comparative genomics– Genome Comparison Techniques- Classical and advanced approaches.

UNIT V Detection of Single Nucleotide Polymorphism; TILLING and Eco- TILLING; Role of transcriptomics, proteomics and metabolomics in linking genome and phenome; Importance of understanding the phenotypes for exploiting the outcome of genomic technologies- Knock out mutant studies and high throughput phenotyping.

UNIT VI Concept of database development, management and bioinformatics; Plant genome projects and application of bioinformatics tools in structural and functional genomics.

Practical:

Chromosome analysis in major field crops - Fluorescence *in situ* hybridization - Comparative genomic hybridization – Comparative analysis of plant genomes using molecular markers – Genetic map construction using molecular markers – Mapping major genes using molecular markers – QTL mapping in plants – Comparison across mapping populations – Understanding the need genetic algorithms in QTL mapping – Plant Genome Databases – Computational tools to explore plant genome databases – Comparative genomics – Comparison of genome sequences using tools of bioinformatics- Advanced genomic technologies: TILLING and Eco-TILLING – DNA Array Technology – Linking genome sequences to phenotypes: Tools of transcriptomics, proteomics and metabolomics.

Suggested Readings

Baxevanis AD & Ouellette BFF. 2001. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. Wiley Interscience.

Brown TA. 2002. *Genomes*. Wiley-LISS.

Caetano-Anolles G & Gresshoff PM. 1998. *DNA Markers: Protocols, Applications and Overviews*. Wiley-VCH.

Cantor CR & Smith CL (2004). *Genomics*. Wiley, New York.

Galas DJ & McCormack SJ. 2002. *Genomic Technologies: Present and Future*. Calster Academic Press.

Jordan BR. 2001. *DNA Microarrays: Gene Expression Applications*. Springer-Verlag.

Liu BH. 1997. *Statistical Genomics: Linkage, Mapping and QTL Analysis*. CRS Press.

Lynch M & Walsh B. 1998. *Genetics and Analysis of Quantitative Traits*. Sinauer Associates.

Mount DW. 2001. *Bioinformatics. Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press..

Palzkill T. 2002. *Proteomics*. Kluwer.

Paterson AH. 1996. *Genome Mapping in Plants*. Academic Press.

Pennington SR & Dunn MJ. 2002. *Proteomics: From Protein Sequence to Function*. Viva Books.

Rampal JB. 2001. *DNA Arrays: Methods and Protocols*. Humana Press.

GP 604 Molecular and Chromosomal Manipulations for Crop Breeding 2+0

Objective: This course focuses on the advanced techniques in analyzing chromosome structure and manipulations for genome analysis in crop species.

Theory:

UNIT I Organization and structure of genome – Genome size – Organization of organellar genomes – Nuclear DNA organization – Nuclear and Cytoplasmic genome interactions and signal transduction; Transcriptional and Translational changes, Inheritance and expression of organellar DNA; Variation in DNA content – C value paradox; Sequence complexity – Introns and Exons – Repetitive sequences – Role of repetitive sequence.

UNIT II Karyotypin – Chromosome banding and chromosome painting; Tracking introgressions using FISH, GISH, loclalization and mapping of genes/genomic segments; Distant hybridization - Role of polyploids in crop evolution and breeding - auto and allopolyploids.

UNIT III Applications of cytogenetical methods for crop improvement; Location and mapping of genes on chromosomes: deficiency method; Interchange genetic consequence, identification of chromosomes involved and gene location; balanced lethal systems, their maintenance and utility; Multiple interchanges-use in producing inbreds, transfer of genes- linked marker methods; Duplication – production and use; Inversions and location of genes; B/A chromosome translocations and gene location.

UNIT IV Trisomics- types, production, breeding behavior and location of genes, use of balanced tertiary trisomics in hybrid seed production; Monosomicsmethods of production, breeding behavior and location of genes; Intervarietal substitutions- allelic and non-allelic interactions; Telocentric method of mapping.

UNIT V Barriers to interspecific and intergeneric hybridization- Behaviour of interspecific and intergeneric crosses; Totipotency of cells – Morphogenesis: *in vivo* and *in vitro* – Meristem culture – anther and pollen culture – ovule, ovary, embryo and endosperm culture – protoplast isolation and culture – protoplast fusion, Different pathways of *in vitro* morphogenesis – organogenesis and somatic embryogenesis; *in vitro* mutant/somaclone selection for biotic and abiotic stresses.

Suggested Readings:

Clark MS & Wall WJ. 1996. *Chromosomes: The Complex Code*. Chapman & Hall.

Conger BV. (Ed.). 1981. *Cloning Agricultural Plants via in vitro Techniques*. CRC Press.

Constabel F & Vasil IK. (Eds.). 1988. *Cell Culture and Somatic Cell Genetics of Plants*. Vol. V. *Cell Culture and Phytochemicals in Plant Cell Cultures*. Academic Press.

Lal R & Lal S. (Eds.). 1990. *Crop Improvement Utilizing Biotechnology*. CRC Press.

Mantel SH & Smith H. 1983. *Plant Biotechnology*. Cambridge University Press.

Sen SK & Giles KL. (Eds.). 1983. *Plant Cell Culture in Crop Improvement*. Plenum Press.

GP 605 Advances in Plant Breeding Systems 2+0

Objective: To impart theoretical knowledge and computation methods for non allelic interactions, mating designs and component analysis and their significance in plant breeding.

Theory:

UNIT I Facts about plant breeding before the discovery of Mendelism; Evolutionary concepts of genetics and plant breeding - Flower development and its importance; genes governing the whorls formation and various models proposed; Mating systems and their exploitation in crop breeding; Types of pollination, mechanisms promoting cross pollination.

UNIT II Self- incompatability and sterility – Types of self incompatability: Homomorphic (sporophytic and gametophytic) and heteromorphic - Breakdown of incompatibility Floral adaptive mechanisms - Spatial and temporal - Genetic and biochemical basis of self incompatibility; Sterility male and female sterility – Types of male sterility: genic, cytoplasmic and cytoplasmic-genic; Exploitation in monocots and dicots, difficulties in exploiting CGMS system in dicots – Case studies and breeding strategies; Nucleocytoplasmic interactions with special reference to male sterility – Genetic , biochemical and molecular bases.

UNIT III Population formation by hybridization - Types of populations – Mendelian population, gene pool, composites, synthetics etc.; Principles and procedures in the formation of a complex population; Genetic basis of population improvement.

UNIT IV Selection in self fertilizing crops; Creation of genetic variability selection – methods - Selection methods: mass selection, pureline selection, pedigree method (selection in early generations vs advanced generations); Backcross, polycross and test cross.

UNIT V Selection in cross fertilizing crops – Polycross and topcross selections, Mass and recurrent selection methods and their modifications – Mass selection: grided mass selection, ear to row selection, modified ear to row selection; Convergent selection, divergent selection; Recurrent selection: Simple recurrent selection and its modifications (restricted phenotypic selection, selfed progeny selection and full sib recurrent selection) - Recurrent selection for general combining ability (GCA) Concepts and utilization - Recurrent selection for specific combining ability (SCA) – usefulness in hybrid breeding programmes - Reciprocal recurrent selection (Half sib reciprocal recurrent selection, Half sib reciprocal recurrent selection with inbred tester and Full sib reciprocal recurrent selection); Selection in clonally propagated crops – Assumptions and realities.

UNIT VI Genetic engineering technologies to create male sterility; Prospects and problems Use of self-incompatability and sterility in plant breeding – case studies; - Fertility restoration in male sterile lines and restorer diversification programmes - Conversion of agronomically ideal genotypes into male steriles – Concepts and breeding strategies; Case studies - Generating new cytonuclear interaction system for diversification of male steriles - Stability of male sterile lines – Environmental influence on sterility– Environmentally Induced Genic Male Sterility (EGMS) – Types of EGMS; Influence on their expression, genetic studies; Photo and thermo sensitive genetic male sterility and its use in heterosis breeding - Temperature sensitive genetic male sterility and its use heterosis breeding - Apomixis and its use in heterosis breeding - Incongruity – Factors influencing incongruity - Methods to overcome incongruity mechanisms.

Suggested Readings:

Agarwal RL. 1996. *Fundamentals of Plant Breeding and Hybrid Seed Production*. Oxford & IBH.
Allard RW. 1966. *Principles of Plant Breeding*. John Wiley & Sons.
Briggs FN & Knowles PF. 1967. *Introduction to Plant Breeding*. Reinhold.
Fehr WR. 1987. *Principles of Cultivar Development: Theory and Technique*. Vol I. Macmillan.
Hayes HK, Immer FR & Smith DC. 1955. *Methods of Plant Breeding*. McGraw-Hill.
Mandal AK, Ganguli PK & Banerji SP. 1995. *Advances in Plant Breeding*. Vol. I, II. CBS.
Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin.
Sharma JR. 1994. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
Simmonds NW. 1979. *Principles of Crop Improvement*. Longman.
Singh BD. 1997. *Plant Breeding: Principles and Methods*. 5th Ed., Kalyani.
Singh P. 1996. *Essentials of Plant Breeding*. Kalyani.
Welsh JR. 1981. *Fundamentals of Plant Genetic and Breeding*. John Wiley.
Williams W. 1964. *Genetical Principles and Plant Breeding*. Blackwell.

GP 607 Breeding Designer Crops 2+1

Objective: To impart theoretical knowledge and practical know-how towards physiological efficiency, nutritional enhancement, biofortification and industrial/pharma applications in plant breeding.

Theory:

UNIT I Breeding of crop ideotypes; Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement, special compounds-proteins, vaccines, gums, starch and fats.

UNIT II Physiological efficiency as a concept, parametric and whole plant physiology in integrated mode; Physiological mechanism of improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement.

UNIT III Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships, effect of suboptimal conditions on cardinal plant growth and development processes, enhancing input use efficiency through genetic manipulations.

UNIT IV Breeding for special traits viz. oil, protein, vitamins, amino acids etc.; Concept of biopharming and development of varieties producing targeted compounds, nutraceuticals and industrial products; Success stories in vaccines, modified sugars, gums and starch through biopharming T V:- Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management

Practical:

Demonstration of plant responses to stresses through recent techniques; Water use efficiency, transpiration efficiency, screening techniques under stress conditions such as electrolyte leakage, TTC, chlorophyll fluorescence, canopy temperature depression, stomatal conductance, chlorophyll estimation, heat/drought/salt shock proteins.

Suggested Readings:

Balint A. 1984. *Physiological Genetics of Agricultural Crops*. AK Ademiaikiado.

Hay RK. 2006. *Physiology of Crop Yield*. 2nd Ed. Blackwell.

Pessarakli M. 1995. *Handbook of Plant and Crop Physiology*. Marcel Dekker.

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

GP 608 Advances in Breeding of Major Field Crops 3+0

Objective: To provide insight into recent advances in improvement of cereals, millets and non cereal crops using conventional and modern biotechnological approaches.

Theory:

UNIT I History, description, classification, origin and phylogenetic relationship, genome status in cultivated and alien species of major cereals, millets and non cereal crops like Rice, Wheat, Maize, Pearlmillet, Sorghum , Pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc.

UNIT II Breeding objectives in rice, wheat, maize, pearlmillet, sorghum, pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Genetic resources and their utilization; Genetics of quantitative and qualitative traits.

UNIT III Breeding for value addition and resistance to abiotic and biotic stresses.

UNIT IV Conventional (line breeding, population improvement, hybrids) and other approaches (DH Populations, Marker Assisted Breeding, Development of new male sterility systems), transgenics.

UNIT V National and International accomplishments in genetic improvement of major field crops and their seed production.

Suggested Readings:

Chopra VL. 2001. *Breeding Field Crops - Theory and Practice*. Oxford & IBH.

Davis DD.1978. *Hybrid Cotton Specific Problems and Potentials*. Adv. Agron. 30: 129-157.

Heyne EG. 1987. *Wheat and Wheat Improvement*. 2nd Ed. ASA, CSSA, SSSA Inc Publ.

Khairwal, IS, Rai KN & Harinaryanan H. (Eds.). 1999. *Pearl Millet Breeding*. Oxford & IBH.

Khairwal I, Ram C & Chhabra AK. 1990. *Pearl Millet Seed Production and Technology*. Manohar Publ.

Nagarajan S, Singh G & Tyagi BS. 1998. *Wheat Research Needs Beyond 2000 AD*. Narosa.

Nanda JS. 2000. *Rice Breeding and Genetics - Research Priorities and Challenges*. Oxford & IBH.

Rao VS, Singh G & Misra SC. 2004. *Wheat: Technologies for Warmer Areas*. Annamaya Publ.

Reynolds MP, Rajaram S, McNab A. 1996. *Increasing Yield Potential in Wheat: Breaking the Barriers*. Proc. Workshop held in Ciudad, Obregon, Sonora, Mexico. Seth BL, Sikka SM, Dastur RH, Maheshwari P, Rangaswamy NS & Josi AB. 1960. *Cotton in India – A Monograph*. Vol. I. ICAR.

Singh BD. 2006. *Plant Breeding - Principles and Methods*. Kalyani.

Singh P & Singh S. 1998. *Heterosis Breeding in Cotton*. Kalyani.

Singh P. 1998. *Cotton Breeding*. Kalyani.

Singh S & Singh P. 2006. *Trends in Wheat Breeding*. Kalyani Publ.

Minor course

PP 605 **Climate Change and Crop Growth** **2+0**

Objective To impart knowledge about climate change and its implication to crop growth.

Theory

UNIT I History and evidences of climate change and its implications. Effect of climate change on monsoons, hydrological cycle and water availability.

UNIT II Natural and anthropogenic activities and agricultural practices on GHG production, Monitoring of greenhouse gases and their influence on global warming and climate change, Ozone depletion leading to increased ionizing radiations and its implications on crop growth.

UNIT III Long-term and short-term projections of climate change effects on natural vegetations and ecosystems, crop-pest interaction, area shift, food production and supply.

UNIT IV Approaches to mitigate climate change through studies on plant responses.

UNIT V Direct and indirect effects of climate change on plant processes – phenology, net carbon assimilation, water relations, grain development and quality, nutrient acquisition and yield.

UNIT VI Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of "Genome wide mutants" to identify genes/processes for improved adaptation to changing environments

UNIT VII International conventions and global initiatives on Carbon sequestration, carbon trading.

Suggested Readings

Abrol YP & Gadgil S. (Eds.). 1999. Rice in a Changing Climate.

Reddy KR & Hodges HF. 2000. Climate Change and Global Crop Productivity. CABI.

Watson RT, Zinyowera MC & Moss RH. 1998. The Regional Impacts of Climate Change - an Assessment of Vulnerability. Cambridge Univ. Press. 98

PP 608 Seed Physiology 2+1

Objective

To apprise students regarding seed germination, dormancy and physiological processes involved in regulation of seed development

Theory

UNIT I Seed and fruit development, seed and fruit abortion, proximate mechanism of seed and fruit abortion. Hereditary and environmental effect on seed development. Gene imprints and seed development. 100

UNIT II Importance of seeds, seed structure and function, physiological and biochemical changes, environmental influences, physiology of seed and fruit development; seed and fruit abortion and means to overcome it; proximate mechanisms of seed and fruit abortion.

UNIT III Structure of seeds and their storage resources, seed developmental patterns and source of assimilates for seed development.

UNIT IV Pathway of movement of assimilates in developing grains of monocots and dicots, Chemical composition of seeds, Storage of carbohydrates, proteins and fats in seeds and their biosynthesis.

UNIT V Seed respiration, mitochondrial activity, Seed ageing, Mobilization of stored resource in seeds, Chemistry of oxidation of starch, proteins and fats, Utilization of breakdown products by embryonic axis.

UNIT VI Control processes in mobilization of stored resources, Role of embryonic axes, Gibberllin and a-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, Role of LEA proteins.

UNIT VII Seed viability, Physiology of and means to prolong seed viability, Seed vigour concept, importance, measurement; invigoration methods and physiological basis of it, Seed dormancy, types and regulation, Means to overcome seed dormancy.

Practical

- Determination of seed storage proteins, Sink drawing ability of ovules, empty ovule technique, Alpha-amylase activity in germinating seeds.
- Role of GA in inducing amylase activity. Role of embryo in GA induced amylase activity, Protease and lipase activity in germinating seeds.
- Seed viability test and accelerated ageing test.
- Seed hardening/osmotic priming of seeds, seed respiration rates, seed viability losses through membrane leakage studies.

Suggested Readings

Bewley JD & Black M. 1985. Seed Physiology of Development and Germination. Plenum Publ.
Copeland LO & McDonald MB. Principles of Seed Sciences and Technology. Burgers Publ. Co.
Srivastav L M. Plant Growth and Development - Hormones and Environment, Academic Press. 101

Minor course

AGRON 606 Advances in Weed Management (2+0)

Objective To teach about the changing weed flora, new herbicides, their resistance toxicity, antidotes and residue management under different cropping systems

Theory

UNIT I Crop-weed competition in different cropping situations; changes in weed flora, various causes and affects.

UNIT II Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action; selectivity of herbicides and factors affecting them.

UNIT III Climatic factors and phytotoxicity of herbicides; fate of herbicides in soil and factors affecting them, residue management of herbicides, adjuvants.

UNIT IV Advances in herbicide application techniques; herbicide resistance; antidotes and crop protection, compatibility of herbicides of different groups; compatibility of herbicides with other pesticides.

UNIT V Development of transgenic herbicide resistant crops; herbicide development, registration procedures.

UNIT VI Relationship of herbicides with tillage, fertilizer and irrigation; bioherbicides, allelochemical, herbicide bioassays.

Suggested Readings

Aldrich RJ & Kramer R.J. 1997. Principles in Weed Management. Panama Publ.

Ashton FM & Crafts AS. 1981. Mode of Action of Herbicides. 2nd Ed.Wiley-Inter Science.

Gupta OP. 2000. Weed Management – Principles and Practices. Agrobios.

Mandal RC. 1990. Weed, Weedicides and Weed Control - Principles and Practices. Agro-Botanical Publ.

Rao VS. 2007. Principles of Weed Science. Oxford & IBH.

Ross MA & Carola Lembi A. 1999. Applied Weed Science. 2nd Ed. Prentice Hall.

Subramanian SAM & Kumar R.J. 1997. All About Weed Control. Kalyani.

Zimdahl RL. 1999. Fundamentals of Weed Science. 2nd Ed. Academic Press.

Kewat, M.L. & Sharma, R.S. (2007). A practical manual for weed control, College of Agriculture, JNKVV, Jabalpur

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. 101

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.

STAT 521 Applied Regression Analysis 2+1

Objective The students would be exposed to the concepts of correlation and regression. Emphasis will be laid 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 Problem of correlated errors; Auto correlation; Durbin Watson Statistics; Removal of auto correlation by transformation; 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; regression approach applied to analysis of variance in one way classification.

UNIT IV Heteroscedastic models, Concept of nonlinear regression and fitting of quadratic, exponential and power 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, residuals and their applications in outlier detection; Handling of correlated errors, multicollinearity; Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

Suggested Readings

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.

Koutsoyiannis A. 1978. Theory of Econometrics. MacMillan.

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 is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students a hands on experience in the analysis of their research data. This course is useful to all disciplines.

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 multi-classified experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

UNIT IV Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.

UNIT V Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data; Spatial analysis; Neural networks.

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, Estimation of trimmed means etc., 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, contrast and its testing, pairwise comparisons; Multiway classified analysis of variance - cross-classification, nested classification, factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components; Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets - maximum likelihood, ANOVA, REML, MINQUE; 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, working out moving averages. Spatial analysis; Neural networks.

Suggested Readings

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.

Snell EJ & Simpson HR. 1991. Applied Statistics A Handbook of GENSTAT Analyses. Chapman & Hall.

Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.

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.

http//www.stat.sc.edu/~grego/course/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%2Data.html.

PGS 501 Library and Information Services 1(0+1)

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

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

PGS 504 Basic Concepts in Laboratory Techniques 1(0+1)

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

Practical Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralization 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, sand bath, water bath, oil bath; 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 Agriculture Research, Research Ethics and Rural Development Program's 1(1+0)

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

Theory

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

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

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

Suggested Readings

Bhalla GS & Singh G. 2001. Indian Agriculture- Four Decades of Development. Sage Publ.

Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.

Rao BSV. 2007. Rural Development Strategies and Role of Institutions- Issues, Innovations and Initiatives.

Singh K.. 1998. Rural Development Principles, Policies and Management. Sage Publ.

PGS 506 Disaster Management 1(1+0)

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

PGS 502 Technical Writing and Communications Skills 1(0+1)

Objective

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

Practical

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

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

Suggested Readings

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 Intellectual Property and Its management in Agriculture 1(1+0)

Objective

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

Theory

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

Suggested Readings

Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.

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.