M Sc. (Ag) Genetics and Plant Breeding

Ist semester

Sub. Code	Subject Title	L	P	Total
01MSC20101	Principles of Genetics	2	1	3(2+1)
01MSC20102	Principles of Cytogenetics	2	1	3(2+1)
01MSC20103	Principles of Plant Breeding	2	1	3(2+1)
01MSC20104	Statistical Methods	2	1	3(2+1)
01MSC20301	DACA	0	1	1(0+1)
	Total	**8**	**5**	**13(8+5)**

01MSC20101 Principles of Genetics 3(2+1)

Objective

This course is aimed at understanding the basic concepts of genetics, helping students to develop their analytical, quantitative and problemsolving skills from classical to molecular genetics.

Theory

UNIT I

Beginning of genetics; Cell structure and cell division; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Chromosomal theory of inheritance.

UNIT II

Multiple alleles,Gene interactions. Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits; Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes, Somatic cell genetics, Extra chromosomal inheritance.

UNIT III

Population - Mendelian population – Random mating population - Frequencies of genes and genotypes-Causes of change: Hardy-Weinberg equilibrium.

UNIT IV

Structural and numerical changes in chromosomes; Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic code; Protein biosynthesis.

UNIT V

Genetic fine structure analysis, Allelic complementation, Split genes, Transposable genetic elements, Overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters.

UNIT VI

Regulation of gene activity in prokaryotes; Molecular mechanisms of mutation, repair and suppression; Bacterial plasmids, insertion (IS) and transposable (Tn) elements; Molecular chaperones and gene expression. Gene regulation in eukaryotes, RNA editing.

UNIT VII

Gene isolation, synthesis and cloning, genomic and cDNA libraries, PCRbased cloning, positional cloning; Nucleic acid hybridization and immunochemical detection; DNA sequencing; DNA restriction and modification, Anti-sense RNA and ribozymes; Micro- RNAs (miRNAs).

UNIT VIII

Genomics and proteomics; Functional and pharmacogenomics; Metagenomics.

UNIT IX

Methods of studying polymorphism at biochemical and DNA level; Transgenic bacteria and bioethics; Gene silencing; genetics of mitochondria and chloroplasts.

UNIT X

Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics.

Practical

Laboratory exercises in probability and chi-square; Demonstration of genetic principles using laboratory organisms; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification - Electrophoresis – basic principles and running of amplified DNA - Extraction of proteins and isozymes – use of *Agrobacterium* mediated method and Biolistic gun; practical demonstrations - Detection of transgenes in the exposed plant material; visit to transgenic glasshouse and learning the practical considerations.

Suggested Readings

Gardner EJ & Snustad DP. 1991. *Principles of Genetics*. John Wiley & Sons. Klug WS & Cummings MR. 2003. *Concepts of Genetics*. Peterson Edu. Lewin B. 2008. *Genes IX*. Jones & Bartlett Publ. Russell PJ. 1998. *Genetics*. The Benzamin/Cummings Publ. Co. Snustad DP & Simmons MJ. 2006. *Genetics*. 4th Ed. John Wiley & Sons. Strickberger MW. 2005. *Genetics (III Ed)*. Prentice Hall, New Delhi, India Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs. Uppal S, Yadav R, Subhadra & Saharan RP. 2005. *Practi*

01MSC20102 Principles of Cytogenetics 3(2+1)

Objective

To provide insight into structure and functions of chromosomes, chromosome mapping, polyploidy and cytogenetic aspects of crop evolution.

Theory

UNIT I

Architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; Artificial chromosome construction and its uses; Special types of chromosomes.

UNIT II

Chromosomal theory of inheritance – Cell Cycle and cell division – mitosis and meiosis; Differences, significance and deviations – Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over- mechanisms and theories of crossing over- recombination models, cytological basis, - Variation in chromosome structure: Evolutionary significance - Introduction to techniques for karyotyping; Chromosome banding and painting - *in situ* hybridization and various applications.

UNIT III

Structural and Numerical variations of chromosomes and their implications Symbols and terminologies for chromosome numbers - euploidy - haploids, diploids and polyploids ; Utilization of aneuploids in gene location - Variation in chromosome behaviour – somatic segregation and chimeras – endomitosis and somatic reduction ; Evolutionary significance of chromosomal aberrations - balanced lethals and chromosome complexes.

UNIT IV

Inter-varietal chromosome substitutions; Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids vs allopolyploids—Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer – Alien addition and substitution lines – creation and utilization; Apomixis - Evolutionary and genetic problems in crops with apomixes.

UNIT V

Reversion of autopolyploids to diploids; Genome mapping in polyploids – Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale and brassica) – Hybrids between species with same chromosome number, alien translocations – Hybrids between species with different chromosome number; Gene transfer using amphidiploids - Bridge species.

UNIT VI

Fertilization barriers in crop plants at pre-and postfertilization levels- *In vitro* techniques to overcome the fertilization barriers in crops; Chromosome manipulations in wide hybridization ; case studies – Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical

Learning the cytogenetics laboratory, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning etc. - Microscopy: various types of microscopes, - Observing sections of specimen using Electron microscope; Preparing specimen for observation – Fixative preparation and fixing specimen for light microscopy studies in cereals - Studies on the course of mitosis in wheat, pearl millet - Studies on the course of mitosis in onion and *Aloe vera* - Studies on the course of meiosis in cereals, millets and pulses - Studies on the course of meiosis in oilseeds and forage crops – Using micrometers and studying the pollen grain size in various crops -Various methods of staining and preparation of temporary and permanent slides - Pollen germination *in vivo* and *in vitro;* Microtomy and steps in microtomy; Agents employed for the

induction of various ploidy levels; Solution preparation and application at seed, seedling level - Identification of polyploids in different crops - Induction and identification of haploids; Anther culture and Ovule culture – Morphological observations on synthesized autopolyploids - Observations on C-mitosis, learning on the dynamics of spindle fibre assembly – Morphological observations on alloployploids - Morphological observations on aneuploids Cytogenetic analysis of interspecific and intergeneric crosses - Maintenance of Cytogenetic stocks and their importance in crop breeding - Various ploidy levels due to somaclonal variation ; Polyploidy in ornamental crops. -Fluorescent *in situ* hybridization (FISH)- Genome *in situ* hybridization GISH.

Suggested Readings

Becker K & Hardin. 2004. *The World of Cell*. 5th Ed. Pearson Edu. Carroll M. 1989. *Organelles*. The Guilford Press.

Charles B. 1993. *Discussions in Cytogenetics*. Prentice Hall.14 Darlington CD & La Cour LF. 1969. *The Handling of Chromosomes*. Georger Allen & Unwin Ltd.

Elgin SCR. 1995. Chromatin Structure and Gene Expression. IRL Press.

Gray P. 1954. The Mirotomist's Formulatory Guide. The Blakiston Co.

Gupta PK & Tsuchiya T. 1991. Chromosome Engineering in Plants: Genetics, Breeding and Evolution. Part A. Elsevier.

Gupta PK. 2000. *Cytogenetics*. Rastogi Publ.

Johannson DA. 1975. *Plant Microtechnique*. McGraw Hill.

Karp G. 1996. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons.

Khush GS. 1973. *Cytogenetics of Aneuploids*. Academic Press.

Sharma AK & Sharma A. 1988. *Chromosome Techniques: Theory and Practice*.

Butterworth. Sumner AT. 1982. *Chromosome Banding*. Unwin Hyman Publ.

Swanson CP. 1960. *Cytology and Cytogenetics*. Macmillan & Co.

01MSC20103 Principles of Plant Breeding 3(2+1)

Objective

To impart theoretical knowledge and practical skills about plant breeding objectives, modes of reproduction and genetic consequences, breeding methods for crop improvement.

Theory

UNIT I

History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants- Centres of Origin-biodiversity and its significance.

UNIT II

Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotypeenvironment interaction; General and specific combining ability; Types of

gene actions and implications in plant breeding; Plant introduction and role of plant genetic resources in plant breeding.

UNIT III

Self-incompatibility and male sterility in crop plants and their commercial exploitation.

UNIT III

Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in selfpollinated crops (diallel selective mating approach).

UNIT IV

Breeding methods in cross pollinated crops; Population breeding-mass selection and earto- row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and interpopulation improvement and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds.

UNIT V

Breeding methods in asexually/clonally propagated crops, clonal selection apomixes, clonal selection.

UNIT VI

Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Transgressive breeding.

UNIT VII

Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses.

UNIT VIII

Cultivar development- testing, release and notification, maintenance breeding, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical

Floral biology in self and cross pollinated species, selfing and crossing techniques. Selection methods in segregating populations and evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance; Maintenance of experimental records; Learning techniques in hybrid seed production using male-sterility in field crops.

Suggested Readings

Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.

Chopra VL. 2001. *Breeding Field Crops*. Oxford & IBH.

Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.

Gupta SK. 2005. *Practical Plant Breeding*. Agribios.

Pohlman JM & Bothakur DN. 1972. *Breeding Asian Field Crops*. Oxford & IBH.

Roy D. 2003. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ.House.

Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.

Simmonds NW. 1990. *Principles of Crop Improvement*. English Language Book Society.
Singh BD. 2006. *Plant Breeding*. Kalyani. Singh P. 2002. Objective Genetics and Plant Breeding. Kalyani. Singh P. 2006. Essentials of Plant Breeding. Kalyani.
Singh S & Pawar IS. 2006. Genetic Bases and Methods of Plant Breeding.CBS.

01MSC20104 Statistical Methods 3(2+1)

1. Probability: Definition of Probability, addition and Multiplicative laws of probability. Fitting of Binomial, Poisson and normal distribution.
2. Correlation and Regression: Karl-Pearson correlation coefficient, Spearman rank Correlation, Partial Correlation, multiple correlation coefficients. Linear Regression, Multiple linear regression upto two independent variables.
3. Tests of Hypothesis: Introduction and concept of tests of hypothesis, t-test of significance of single mean, two means, paired t-test, test of significance of correlation coefficient and partial correlation coefficient. F-test test of significance of two variance, test of significance of multiple correlation coefficient. X2 test of significance of variance, goodness of fit and independence of attributes. Parametric versus non-parametric text, binomial test, sign test, Wilcoxton test
4. Analysis of Variance ; Analysis of variance for one way, two-way classification with equal cell frequencies per cell, transformation of data, concept of critical difference and Duncan's multiple range test.
5. Design of Experiment: Principles of design, selection of experimental material, uniformity trial, determination of size and shape of plots. Experiments in farmer's field. Layout and Analysis of RBD and LSD including one missing value, combined experiments in RBD.
6. Factorial experiments: Concept of main affect and interaction in 22, 23 experiment,partial confounding and complete confounding in 23 experiment.
7. Other Design: Layout and analysis of split plot design, split-split plot design, strip plot design, cross over design and balanced incomplete block design.
8. Response surfaces: Fitting of quadratic response curve, determination of optimum level of a factor by quadratic equation, Mitscherlich equation. Books Recommended

1. Statistical Procedure for Agricultural Research. By: Kwanchai-a Gomes Arturo a.Gomez, John Wileye and Sons. M.Sc. Agriculture (Hons) Parts I & II 18

2. A text book of Agricultural Statistics.By:R.Rangaswamy, New Age International Pvt. Ltd.

3. Statistics for Agricultural Sciences.By: G. Nageswar Rao,Oxford and IBH Publishing Co.

4. Statistical Analysis of Non normal data, By: J.V. Deshpande, A.P.Gore, A. Shanubhogue,

New age International Publishers Ltd.

5. Statistical methods in Animal Sciences, By: V.N. Amble, Indian Society Agricultural

Statistics (New Delhi)

M.Sc. (Ag) Genetics and Plant Breeding

II nd semester

Sub. Code	Subject Title	L	P	Total
02MSC20101	METHODS OF PLANT BREEDING	2	1	3(2+1)
02MSC20102	PRINCIPLES OF QUANTITATIVE GENETICS	2	1	3(2+1)
02MSC20103	MOLECULAR GENETICS	2	1	3(2+1)
02MSC20104	BASIC DESIGN AND EXPERIMENT	2	1	3(2+1)
02MSC20105	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	0	1	1(0+1) NC
02MSC20301	DACA	0	1	1(0+1)
	Total	8	6	14(8+6)

02MSC20101 Methods of plant breeding 2+1

Objective

To impart theoretical knowledge and practical skills about plant breeding objectives, modes of reproduction and genetic consequences, breeding methods for crop improvement.

Theory

Unit-I

Introduction-historical aspects; Development of heterosis concept, genetic, physiological and molecular basis of heterosis; Inbreeding depression; Hybrid breeding methodology-development and improvement of heterotic pool, and inbred lines, evaluation of inbred lines and hybrids, nature and number of testers, combining ability and performance per se, prediction of hybrid performance.

Unit-II

Breeding methods of self-pollinated crops : Pedigree and bulk selection and their genetic consequences, Grid selection (adoption of honey-comb,fan or other such designs) in breeding populations; Multiline- clean and

dirty crop approach, genetic consequences, advantages and disadvantages;Recurrent selection and hybrid breeding.

Unit-III

Breeding methods for cross pollinated crops : Mass selection, recurrentselection and population improvement; Intra-population improvementselectionbased on individual, family and combining ability; Inter-population

improvement; Breeding composite and synthetic populations.

Unit-IV

Hybrid breeding : Hybrids in self and cross pollinated crops - their geneticbases, heterotic pool concept; Development and improvement ofheterotic pools and inbred lines, evaluation of inbred lines and hybrids;

Production of hybrid seed - use of malesterility & its restoration mechanismsand genetic manipulation in hybrid breeding, apomixis in fixingheterosis.Genetic characteristics of pure lines, inbreds, hybrids, clones, mixtures& multilines, composites and synthetics, their maintenance and multiplication.

Practical

Floral biology in self and cross pollinated species, selfing and crossing techniques.Selection methods in segregating populations and evaluation of breeding material;Analysis of variance (ANOVA); Estimation of heritability and genetic advance;Maintenance of experimental records; Learning techniques in hybrid seed production
using male-sterility in field crops.

Suggested Readings

Allard RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.
Chopra VL. 2001. *Breeding Field Crops*. Oxford & IBH.
Chopra VL. 2004. *Plant Breeding*. Oxford & IBH.
Gupta SK. 2005. *Practical Plant Breeding*. Agribios.
Pohlman JM & Bothakur DN. 1972. *Breeding Asian Field Crops*. Oxford & IBH.
Roy D. 2003. Plant Breeding, Analysis and Exploitation of Variation. Narosa Publ.House.
Sharma JR. 2001. Principles and Practice of Plant Breeding. Tata McGraw-Hill.
Simmonds NW. 1990. *Principles of Crop Improvement*. English Language Book Society.
Singh BD. 2006. *Plant Breeding*. Kalyani.
Klug WS & Cummings MR 2003. *Concepts of Genetics*. Scot, Foreman & Co. Lewin B. 2008. IX Genes. John Wiley & Sons

02MSC20102 PRINCIPLES OF QUANTITATIVE GENETICS 2+1

Objective

To impart theoretical knowledge and computation skills regarding component of variation and variances, scales, mating designs and gene effects.

Theory

UNIT I

Mendelian traits *vs* polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and 16 environmental - non-allelic interactions; Nature of gene action - additive, dominance, epistatic and linkage effects.

UNIT II

Principles of Anaylis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance.

UNIT III

Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D2 analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance.

UNIT IV

Generation mean analysis; Mating designs- Diallel, partial diallel, line x tester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for GxE analysis and stability parameters; AMMI analysis, principles and interpretation.

UNIT V

QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic analysis; Marker assisted selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS.

Practical

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D2 analysis - Grouping of clusters and interpretation Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II – Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results – NCD and their interpretations - Line x tester analysis and interpretation of results – Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression - Generation mean analysis: Analytical part and Interpretation - Estimation of different types of gene actions.

Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - Construction of saturated linkage maps and QTL mapping - Strategies for QTL mapping; statistical methods in QTL mapping; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) – use of softwares in analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model - Principal Component Analysis model - Additive and multiplicative model - Shifted 17 multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes.

Suggested Readings

Bos I & Caligari P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall. Falconer DS & Mackay J. 1998. Introduction to Quantitative Genetics. Longman.

Mather K & Jinks JL. 1971. *Biometrical Genetics*. Chapman & Hall. Mather K & Jinks JL. 1983. Introduction to Biometrical Genetics. Chapman & Hall.

Nadarajan N & Gunasekaran M. 2005. Quantitative Genetics and Biometrical Techniques in Plant Breeding. Kalyani.

Naryanan SS & Singh P. 2007. 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.

02MSC20103 MOLECULAR GENETICS 2+1

Objective

To impart knowledge in theory and practice about cell structure, organelles and their functions, molecules like proteins and nucleic acids.

Theory

UNIT I

Ultrastructure of the cell; Differences between eukaryotic and prokaryotic cells, macromolecules; Structure and function of cell wall, nuclear membrane and plasma membrane; Cellular Organelles – nucleus, plastidschloro/ chromoplast, mitochondria endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes.

UNIT II

Bioenergetics; Ultrastructure and function of mitochondria and biological membranes; Chloroplast and other photosynthetic organelles; Interphase nucleus- Structure and chemical composition; Cell division and physiology of cell division.

UNIT III

Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, DNA transcription and its regulation – Transcription factors and their role; Genetic code, regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes, t-RNAs and translational factors.

UNIT IV

Transposable elements; Mechanisms of recombination in prokaryote; DNA organization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; organelle genomes; Gene amplification and its significance; Proteomics and protein-protein interaction; Signal transduction; Genes in development; Cancer and cell aging.

Practical

Morphological and Gram staining of natural bacteria; Cultivation of bacteria in synthetic medium; Determination of growth rate and doubling time of bacterial cells in culture; Demonstration of bacteriophage by plaque assay method; Determination of soluble protein content in a bacterial culture. Isolation, purification and raising clonal population of a bacterium; Biological assay of bacteriophage and determination of phage population in lysate; Study of lytic cycle of bacteriophage by one step growth experiment; determination of latent period and burst size of phages per cell; Quantitative estimation of DNA, RNA and protein in an organism; Numericals: problems and assignments.

Suggested Readings

Bruce A.2004. *Essential Cell Biology*. Garland.

Karp G.2004. Cell and Molecular Biology: Concepts and Experiments. John Wiley.

Klug WS & Cummings MR 2003. *Concepts of Genetics*. Scot, Foreman & Co. Lewin B. 2008. IX Genes. John Wiley & Sons

Lodish H, Berk A & Zipursky SL. 2004. *Molecular Cell Biology*. 5th Ed. WH Freeman.

Nelson DL & Cox MM. 2005. Lehninger's Principles of Biochemistry. WH Freeman & Co.

Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.

Schleif R.1986. *Genetics and Molecular Biology*. Addison-Wesley Publ. Co.

02MSC20104 Basic Design and Experiment 3 (2+1)

Theory

Unit I

Elements of linear estimation, Gauss Markoff Theorem, relationship between BLUEs andlinear 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; Basicprinciples 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 Latinsquare design; orthogonal Latin squares, mutually orthogonal Latin squares (MOLS), Youdensquare designs, Graeco Latin squares.

Unit IV

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

Unit V

Factorial experiments, confounding in symmetrical factorial experiments (2*n* and 3*n* series),partial and total confounding, fractional factorials, asymmetrical factorials.

Unit VI

Designs for fitting response surface; Cross-over designs. Missing plot technique; Split plotand 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 ofdata 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; 2n, 3n 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. Visit to research stations.

Suggested Readings

Chakrabarti MC. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publ. House.

Cochran WG & Cox DR. 1957. *Experimental Designs*. 2nd Ed. John Wiley.

Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. Springer.

Dey A & Mukerjee R. 1999. *Fractional Factorial Plans*. John Wiley.

Dey A 1986. *Theory of Block Designs*. Wiley Eastern.

Hall M Jr. 1986. *Combinatorial Theory*. John Wiley.

John JA & Quenouille MH. 1977. *Experiments: Design and Analysis*. Charles & Griffin.

Kempthorne, O. 1976. Design and Analysis of Experiments. John Wiley.

Khuri AI & Cornell JA. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.

Kshirsagar AM 1983. *A Course in Linear Models*. Marcel Dekker.
Montgomery DC. 2005. *Design and Analysis of Experiments*. John Wiley.

Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*. John Wiley.
Searle SR. 1971. *Linear Models*. John Wiley.
Street AP & Street DJ. 1987. *Combinatorics of Experimental Designs*. Oxford Science Publ.
Design Resources Server. *Indian Agricultural Statistics Research Institute(ICAR), New Delhi-110012, India*. www.iasri.res.in/design

02MSC20105 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE 0+1

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 bio- diversity 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.

III sem Genetics and Plant Breeding

Sub. Code	Subject Title	L	P	Total
03MSC20101	SEED TESTING AND QUALITY CONTROL	2	1	3(2+1)
03MSC20102	TISSUE CULTURE	2	1	3(2+1)
03MSC20103	M.sc (AG) SEMINAR	0	1	1(0+1)
03MSC20104	M.sc (AG) RESEARCH	0	4	4(0+4)
03MSC10301	DACA	0	1	1(0+1)
	Total	**4**	**8**	**12(4+8)**

03MSC20101 SEED TESTING AND QUALITY CONTROL 3(2+1)

National and international history of seed testing. Seed testing networkin India. National and international seed testing rules. Seed testing organizations.Seed sampling, heterogeneity test. Sample receipt and registration.

Physical purity analysis. Determination of other seeds bynumber and determination of other distinguishable for different crops,seedling evaluation. Moisture test. Tetrazolium test - principles, procedureand evaluation. Testing for coated/pelleted seeds. Testing for varietalverification, grow-out test. Seed health. Insect damage. Reporting of

seed testing results. Laboratory layout, furnishing and management.Variability in seed testing results, factors affecting variability, use oftolerance tables in seed testing. Sequential sampling analysis. Seed dormancy,types and methods to break it. Weed seed identification. Preservationand storage of guard samples.History of seed quality control. Importance of good quality seed. Seed

quality standars - definition and concept. Seed quality components andfield standards. Concept and purpose and phases of seed certification.Certification agency. Variety eligibility, class and sources of seed, verification

of seed source. Unit of certification, field inspection and reportingof results, comparing field observations with minimum standards, growouttest, tolerance levels. Seed analyst and his duties. Laboratory evaluation

and packaging, seed lot size and construction of seed lot number,certified seed label, certification tag, validity period of certification. SeedsAct and seed rules and law enforcement. Seed control order. Seed policy.Seed inspectorspowers and duties, inspection procedures andequipments required.OECD- role of OECD in standardizing the seed certification procedures.UPOV- role of UPOV in international seed trade. Consumers Protection

Act. Weights and Measures Act and Packaging Act.

PracticalSampling and submission of samples to seed testing laboratory, sampleregistration, determination of the relative efficacy of various mixing anddividing techniques, obtaining working sample, physical purity analysis

and reporting results. Testing of the germination substrata and determinationof substrate quality, and reporting results. Methods of breakingdrmancy, Tetrazolium test. Moisture test- oven method, moisturemeters. Visit to state seed testing laboratory, Determination of ODV.Field inspection at different crop growth stages- taking field counts indifferent crops. Offtypes, pollen shedders, designated seedborne diseases,counts of the male and female parents in hybird seed production, field inspection report for different crops, field area measurements, isolation distances.

Suggested Readings

1. Agrawal, P.K., and M. Dadlani, 1987. Techniques in Seed Scienceand Technology, South Asian.
2. Agrawal, R.L. 1996. Seed Technology, Oxfored & IBH, PublishingCo., New Delhi.
3. Anon 1965. Field Inspection Manual and Minimum Seed CertificationStandars, NSC Publications, New Delhi.
4. International Seed Testing Association, 1979. Hank book of seedlingevaluations, Scientific Publishers, Jodhpur.
5. International Seed Testing Association, 1987. Hand book of pureseed definitions, Scientific Publishers, Jodhpur.
6. Martin, C. and D. Barkley, 1961. Seed identification manual, Oxford,IBH Publishing Co., Calcutta.
7. Me Donald, M.B. and L.O. Copeland, 1997. Seed Science and TechnologyLaboratory Manual, ScientifiPublisher, Jodhpur.
8. Nema, N.P. 1987. Principles of Seed Certification and Testing, AlliedPublishers Pvt. Ltd., New Delhi.
9. Tunwar, N.S., and S.V. Singh, 1988. Indian Minimum Seed CertificationStandards, Central Seed Certification Board, New Delhi.

03MSC20102 Plant genetic resources 3(2+1)

Historical perspective; Taxonomical classification of cultivated plants;Gene pool: primary, secondary and tertiary; Centres of origin and diversity;Basic genetic resources, derived genetic resources and transgenes;Principles, strategies and practices of exploration, collection, characterization,evaluation and cataloging of PGR; Plant quarantine andphytosanitary certification; Germplasm introduction and exchange; Principlesof in vitro and cryopreservation; Germplasm conservation - in situ,ex situ and on-farm; short -, medium -, long -term conservation strategiefor conservation of orthodox and non-orthodox seed, vegetativelypropagated crops; registration of plant genetic resources; PGR data basemanagement, description, national and international mechanism for PGR
management; Plant genetic resources for food and agriculture (PGRFA),PGR access and benefit sharing; IPR, PBR, UPOV and CBD issues andconsequences; Farmers' rights and privilege; Visti to Gene Bank/National/Regional Research Centres.

Suggested Reading

1. Gautam. P.L., Dabas, B.S., Srivastava, U and Duhoon, S.S. (eds.),1998. Plant Geermplasm Collecting Principles and Procedures,NBPGR Publication, NBPGR, New Delhi.
2. Gautam, P.L., Sharma, G.D. Srivastava, U. Singh, B.M., Ashok Kumar,Saxena, R.K. and Srinivasan, K. (eds.), 2000. 20 Glorious Years ofNBPGR (1976-1996). National Bureau of Plant Genetic Resources,New Delhi.

3. Paroda, R.S. Arora, R.K. and Chandel, K.P.S. (eds.). 1988. Plant GeneticResources; Indian Perspective, NBPGR, New Delhi.
4. Rana, R.S., Singh, Bhag, Koppar, M.N., Rai, M., Kochar, S. andDuhoon, S.S. (eds.) 1994. Plant Genetic Resources: Exploration,Evaluation and Maintenance, NBPGR, New Delhi.
5. Singh, B.B., Singh, N. and Srinivasan, K. (eds.), 1997. Practices andProcedures in Germplasm Conservation.NBPGR Publication, NBPGR,New Delhi.

IV SEM Genetics and plant breeding

Sub. Code	Subject Title	L	P	Total
04MSC20101	HETEROSIS BREEDING	2	1	3(2+1)
04MSC20102	M.SC (AG) RESEARCH	0	6	6(0+6)
04MSC 20103	THESIS VIVA VOCE	0	4	4(0+4)
04MSC20301	DACA	0	1	1(0+1)
	Total	**2**	**12**	**14(2+14)**

04MSC20101 HETEROSIS BREEDING 3(2+1)

Objective

To provide understanding about mechanisms of heterosis and its exploitation for yieldimprovement through conventional and biotechnological approaches.

Theory

Unit I

Historical aspect of heterosis - Nomenclature and definitions of heterosis -Heterosis in naturalpopulation and inbred population; Evolutionary aspects - Genetic consequences of selfingand crossing in self-and cross-pollinated and asexually propagated crops crops.

Unit II

Pre Mendelian and Post-Mendelian ideas - Genetic theories of heterosis – Physiological,Biochemical and molecular factors underlining heterosis; theories and their estimation; -Evolutionary concepts of heterosis.

Unit III

Prediction of heterosis from various crosses- Inbreeding depression, effects of inbreeding ongenotypic frequency and population mean, frequency of inbreeding and residual heterosis inF2 and segregating populations, importance of inbreeding in exploitation of heterosis – casestudies. - Relationship between genetic distance and expression of heterosis – case studies;Divergence and Genetic Distance analyses-morphological and molecular genetic distance in predicting heterosis, Concept of combining ability. Development of heterotic pools ingermplasm/genetic stocks and inbreds, their improvement for increasing heterosis.

Unit IV

Types of male sterility and use in heterosis breeding; Maintenance, transfer and restoration ofdifferent types of male sterility; Use of self -incompatibility in development of hybrids;Hybrid seed production system: 3-line, 2-line ; Development of inbreds and parental lines- A,B and R lines –; Commercial exploitation of heterosis- maintenance breeding of parentallines in hybrids.

Unit V

Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonallypropagated crops; Male sterile line creation and diversification in self pollinated, cross*PG Curricula and*

 -pollinated and asexually propagated crops; problems and prospects; Apomixis in fixingheterosis-concept of single line hybrid.

Unit VI

Organellar heterosis and complementation - Creation of male sterility through geneticengineering and its exploitation in heterosis.

Unit VII

Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops.

Practical

Male sterile line characterization using morphological descriptors; Restorer lineidentification. and diversification of male sterile sources - Male sterile line creation inoilseeds, pulses, cotton and cereals; problems in creation of CGMS system; Ways ofovercoming them ,use of gametocides in inducing male-sterility.- Apomixis: practicalapplications and difficulties in breeding; Estimation from the various models for heterosisparameters -Hybrid seed production infield crops – an account on the released hybridsHybrid breeding at National and International level; Opportunities ahead.

Suggested Readings

Proceedings of *Genetics and Exploitation of Heterosis in Crops* - AnInternational Symposium CIMMYT, 1998.

Akin E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.Ben Hiu Lin. 1998. *Statistical Genomics – Linkage, Mapping and QTL*

Analysis. CRC Press.De Joung G. 1988. *Population Genetics and Evolution*. Springer-Verlag.

Hartl DL. 2000. *A Primer of Population Genetics*. 3rd Ed. Sinauer Assoc.Mettler LE & Gregg TG. 1969. *Population Genetics and Evolution*.Prentice-Hall.Montgomery DC. 2001. *Design and Analysis of Experiments*. 5th Ed.,

Wiley & Sons.Richards AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin. Srivastava S & Tyagi R. 1997. *Selected Problems in Genetics*. Vols. I, II.