M.Sc. (AGRICULTURE)
PLANTS BREEDING & GENETICS

Course Contents & Syllabi

SRI DEV SUMAN UTTARAKHAND University
Badshahithol, Tehri (Grahwal)
Uttarakhand

Course Structure for under Semester Systemto come into force from Academic Session 2013-14.
M.Sc. (AGRICULTURE)
PLANTS BREEDING & GENETICS
SEMESTER SYSTEM

M.Sc. (Agriculture) – PLANT BREEDING & GENETICS

In the area of Plant Breeding & Genetics an effort has been made to retain relevant core concepts and principles of Plant Breeding & Genetics as such. However, new topics and also new courses have been added to infuse new blood in the area. All the courses have been designed/redesigned/updated as per present and future needs.

- New courses have been introduced to keep pace with the latest developments.
- In order to help the students, Course objectives and Suggested readings have also been provided for each course.

- List of Journals have been provided to keep pace with latest developments in the area.
- Suggested Areas of Research have also been added for providing directions to future researches in the area.This programme also requires proper infrastructure, trained teachers, and computers with internet connections. Industrial linkages, guest lectures, industry and farm visits will also be required to provide real life exposure.

M.Sc. (Agriculture) – Plant Breeding & Genetics

COURSE STRUCTURE – AT A GLANCE — FIRST SEMESTER M.M.: 500

PAPER – 101 PRINCIPLES OF GENETICS 100 MARKS:	70External+30 (Internal) = 100 Marks
PAPER – 102 PRINCIPLES OF CYTOGENETICS:	70 External+30 (Internal) = 100
PAPER – 103 PRINCIPLES OF PLANT BREEDING :	70 External+30 (Internal)= 100
PAPER – 104 STATISTICAL METHODS:	70 External+30 (Internal) = 100
PAPER – 105 PRACTICAL I:	50 External Examinations.
PAPER- 106 PRACTICAL II:	50 External Examination

M.Sc. (Agriculture) – Plant Breeding & Genetics

COURSE STRUCTURE – AT A GLANCE — SECOND SEMESTER M.M.: 500

PAPER – 201 PRINCIPLES OF QUANTITATIVE GENETICS:	70External+30 (Internal)= 100
PAPER – 202 MUTAGENESIS AND MUTATION BREEDING:	70External+30 (Internal)= 100
PAPER– 203 CELL BIOLOGY AND MOLECULAR GENETICS:	70External+30 (Internal)= 100
PAPER – 204 EXPERIMENTAL DESIGNS	70External+30(Internal)= 100
PAPER – 205 PRACTICAL I	50 MARKS
PAPER- 205 PRACTICAL II	50 MARKS

M.Sc. (Agriculture) – Plant Breeding & Genetics

COURSE STRUCTURE – AT A GLANCE — THIRD SEMESTER M.M.: 500

PAPER – 301 BIOTECHNOLOGY FOR CROP IMPROVEMENT:	70External+30 (Internal)= 100
PAPER – 302 BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE:	70External+30 (Internal)= 100
PAPER – 303 BREEDING CEREALS, SUGARCANE LEGUMES, OILSEEDS AND FIBRE CROPS:	70External+30 (Internal)= 100
PAPER – 304 HETEROSIS BREEDINGH:	70External+30 (Internal)= 100
PAPER – 305 PRACTICAL-I	50 MARKS
PAPER-306 PRACTICAL II	50 MARKS

M.Sc. (Agriculture) – Plant Breeding & Genetics

COURSE STRUCTURE – AT A GLANCE — FOURTH SEMESTER M.M.: 500

PAPER – 401 MAINTENANCE BREEDING, CONCEPTS OF VARIETY RELEASE SEED PRODUCTION:	70External+30 (Internal)= 100
PAPER– 402 CONSERVATION & UTILIZATION OF PLANT GENETICS RESOURCES:	70External+30 (Internal)= 100
PAPER – 405 PRACTICAL I	50 MARKS
PAPER – 404 DESSERTATION/PROJECT WARK (SEMINAR):	150 MARKS
PAPER – 405 THESIS (THESIS AND VIVA – VOCE) / SPEICAL PAPER :	100 MARKS

FIRST SEMESTER 500 MARKS
SECOND SEMESTER 500 MARKS
THIRD SEMESTER 500 MARKS
FOURTH SEMESTER 500 MARKS
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GRAND TOTAL 2000MARKS
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M. Sc. Ag. Examination in Plant Breeding & Genetics

PROPOSED REGULATIONS

Semesters/Papers	Title of the papers	Theory			Practical	
		External	Internal	Total	Lab course I	Lab course II
		70	30	100	50	50
SEMESTER I						
Paper 101	(Theory Paper)	70	30	100	50	50
Paper 102	(Theory Paper)	70	30	100	50	50
Paper 103	(Theory Paper)	70	30	100	50	50
Paper 104	(Theory Paper)	70	30	100	50	50
Paper 105	**Practical I**	70	30	100	50	50
Paper 106	**Practical II**	70	30	100	50	50

40% Marks Pass in Each External theory papers, Total aggregate of First Semester is 45%

Max. Marks – 500, **Min.Marks – 225**

Semesters/Papers	Title of the papers	Theory			Practical	
		External	Internal	Total	Lab course I	Lab course II
		70	30	100	50	50
SEMESTER II						
Paper 201	(Theory Paper)	70	30	100	50	50
Paper 202	(Theory Paper)	70	30	100	50	50
Paper 203	(Theory Paper)	70	30	100	50	50
Paper 204	(Theory Paper)	70	30	100	50	50
Paper 205	**Practical I**	70	30	100	50	50
Paper 206	**Practical II**	70	30	100	50	50

40% Marks Pass in Each theory papers. Total aggregate of Second Semester is 45%

Max. Marks – 500, **Min.Marks – 225**

Semesters/ Papers	Title of the papers	Theory			Practical	
		External	Internal	Total	Lab course I	Lab course II
		70	30	100	50	50
SEMESTER III		28 MM				
Paper 301	(Theory Paper)	70	30	100	50	50
Paper 302	(Theory Paper)	70	30	100	50	50
Paper 303	(Theory Paper)	70	30	100	50	50
Paper 304	(Theory Paper)	70	30	100	50	50
Paper 305	**Practical I**	70	30	100	50	50
Paper 306	**Practical II**	70	30	100	50	50

40% Marks Pass in Each theory papers. Total aggregate of Third Semester is 45%
Max. Marks – 500, **Min.Marks – 225**

Semesters/ Papers	Title of the papers	Theory			Practical	
		External	Internal	Total	Lab course I	Lab course II
		70	30	100	50	50
SEMESTER IV						
Paper 401(A)	(Theory Paper)	70	30	100		
Paper 402 (B)	(Theory Paper)	70	30	100		
Paper 403	(Theory Paper)	70	30	100		
Paper 404	(Practical I)				50	
Paper 405	SEMINAR	100		100		
Paper 406	THEISI (THESIS AND VIVA-VOCE)	100		100		

40% Marks Pass in Each theory papers. Total aggregate of Third Semester is 45%
Max. Marks – 500, **Min.Marks – 225**

Consolidate Performa for allotments of all semester are as follows:-

First Semester	500	225
Second Semester	500	225
Third Semester	500	225
Fourth Semester	500	225
Grand Total		
======		
	2000	**900**

Note:

1. The research work may be initiated in any of II or III semester but the thesis shall be submitted at the
end of IV semester.
2. The evaluation of seminar presentation shall be done by the departmental committees.

M.Sc. (AGRICULTURE) PLANT BREEDING & GENETICS
FIRST SEMESTER
COURSE CONTENTS – DETAILED SYLLABUS

PAPER – 101: PRINCIPLES OF GENETICS
Objective : -
This course is aimed at understanding the basic concepts of genetics, helping students to develop their analytical, quantitative and problem solving skills from classical to molecular genetics.

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, Sexinfluenced 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, PCR based 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 *Agro-bacterium* 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. *Practical Manual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.

PAPER – 102:PRINCIPLES OF CYTOGENETICS

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

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 overmechanisms 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) –

PAPER – 103: PRINCIPLES OF PLANT BREEDING

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

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, genotype environment 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.
Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multi-line method; Population breeding in self pollinated 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 inter-population 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.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.
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.

PAPER – 104:STATISTICALMETHODS

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. The students are also exposed to correlation and regression, and order statistics and their distributions.Categorical data analysis is also covered in this course.

UNIT I

Descriptive statistics: probability distributions: Discrete probability distributions ~ Bernoulli, Binomial, Poisson, Negative-binomial, Geometric and Hyper Geometric, uniform,multinomial ~ Properties of these distributions and real life examples. Continuous probability distributions ~ rectangular, exponential, Cauchy, normal, gamma, beta of two kinds, Weibull, lognormal, logistic, Pareto. 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, 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.

Suggested Readings

• Agresti A. 2002. *Categorical Data Analysis*. 2nd Ed. John Wiley.
• Arnold BC, Balakrishnan N & Nagaraja HN. 1992. *A First Course in Order Statistics*. John Wiley.
• David HA & Nagaraja HN. 2003. *Order Statistics*. 3rd Ed. John Wiley.
• Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.
• Huber PJ. 1981. *Robust Statistics*. John Wiley.
• Johnson NL, Kotz S & Balakrishnan N. 2000. *Continuous Univariate Distributions*. John Wiley.
• Johnson NL, Kotz S & Balakrishnan N. 2000. *Discrete Univariate Distributions*. John Wiley.
• Marek F. 1963. *Probability Theory and Mathematical Statistics*. John Wiley.
• Rao CR. 1965. *Linear Statistical Inference and its Applications*. John Wiley.
• Rohatgi VK & Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.

SECOND SEMESTER

PAPER – 201:PRINCIPLES OF QUANTITATIVE GENETICS

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

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 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 D 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, Quadrille analysis and Triple Test Cross (TTC) – use of software's 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 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.

PAPER – 202:MUTAGENESIS ANDMUTATION BREEDING

Objective : -To impart the knowledge about general principles of radiation and various tests/methods for detection of radiation effects on the living cells, genetic risks involved and perspectives of advancesmade.

UNIT I

Mutation and its history - Nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations - Detection of mutations in lower and higher organisms – paramutations.

UNIT II

Mutagenic agents: physical -- Radiation types and sources: Ionizing and non-ionizing radiations *viz*., X rays, γ rays, , □ and ß particles, protons, neutrons and UV rays -Radiobiology: mechanism of action of various radiations (, photoelectric absorption, Compton scattering and pair production) and their biological effects –RBE and LET relationships.

UNIT III

Effect of mutations on DNA - Repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects - Dosimetry - Objects and methods of treatment - Factors influencing mutation: dose rate, acute *vs* chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects - Radiation sensitivity and modifying factors: External and internal sources- Oxygen, water content, temperature and nuclear volume.

UNIT IV

Chemical mutagens- Classification - Base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action - Dose determination and factors influencing chemical mutagenesis - Treatment methods using physical and chemical mutagens - Combination treatments; other causes of mutation - direct and indirect action, Comparative evaluation of physical and chemical mutagens.

UNIT V

Observing mutagen effects in M2 generation: plant injury, lethality, sterility, chimeras *etc*., - Observing mutagen effects in M1 generation - Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations -– Mutations in traits with continuous variation.

UNIT VI

Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage *etc*. - Individual plant based mutation analysis and working out effectiveness and efficiency in M3 generation - Comparative evaluation of physical and chemical mutagens for creation of variability in the same species – Case studies.

UNIT VII

Use of mutagens in creating oligogenic and polygenic variations – Case studies - *In vitro* mutagenesis – callus and pollen irradiation; Handling of segregating generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc) in different crops- Procedures for micro-mutations breeding/polygenic mutations- Achievements of mutation breedingvarieties released across the world- Problems associated with mutation breeding.

Practical

Learning the precautions on handling of mutagens; Dosimetry - Studies of different mutagenic agents: Physical mutagens - Studies of different mutagenic agents: Chemical mutagens - Learning on Radioactivity – Production of source and isotopes at BRIT, Trombay - Learning about gamma chamber; Radiation hazards - Monitoring – safety regulations and safe transportation of radioisotopes - Visit to radio isotope laboratory ; learning on safe disposal of radioisotopes - Hazards due to chemical mutagens - Treating the plant propagates at different doses of physical and chemical mutagens - Learning combined mutagenic treatments; Raising the crop for observation - Mutagenic effectiveness and efficiency; Calculating the same from earlier literature - Study of M1 generation – Parameters to be observed; Study of M2 generation – Parameters to be observed; Mutation breeding in cereals and pulses – Achievements made and an analysis - Mutation breeding in oilseeds and cotton – Achievements and opportunities - Mutation breeding in forage crops and vegetative propagated crops; Procedure for detection of mutations for polygenic traits in M2 and M3 generations.

Suggested Readings

- Alper T. 1979. *Cellular Radiobiology*. Cambridge Univ. Press, London.
- Chadwick KH & Leenhouts HP. 1981. *The Molecular Theory of Radiation Biology*. Springer-Verlag.
- Cotton RGH, Edkin E & Forrest S. 2000. *Mutation Detection: A Practical Approach*. Oxford Univ. Press.
- International Atomic Energy Agency. 1970. *Manual on Mutation Breeding*. International Atomic Energy Agency, Vienna, Italy.
- Singh BD. 2003. *Genetics*. Kalyani.
- Strickberger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall.

PAPER – 203:CELL BIOLOGY ANDMOLECULAR GENETICS

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

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, plastids- chloro/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.

UNIT V

Introduction: Gene regulation-purpose; Process and mechanisms in prokaryotes and eukaryotes; Levels of gene controls.Coordinated genetic regulation-examples- Anthocyanin and gene families and maize;Genetic and molecular basis depending on tissue specificity.

UNIT VII

Gene expression-Transposons in plant gene expression, cloning-transposon tagging; Light regulated gene expression-model systems in *Arabidopsis* andmaize; Paramutations and imprinting of genes and genomes.

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.
- Lewin B. 2008. *Genes IX*. John Wiley & Sons.
- Schleif R.1986. *Genetics and Molecular Biology*. Addison-Wesley.
- Russell PJ. 1996. *Essential Genetics*. Blackwell Scientific Publ.
- Brown TA. 2002. *Genomes*. Bios Scientific Publ.
- Tamarin RH. 1999. *Principles of Genetics*. Wm C Brown Publ.
- Griffiths AJF. 2000. *An Introduction to Genetic Analysis*. WH Freeman.
- Hexter W & Yost HT. 1976. *The Science of Genetics*. Prentice Hall.
- Singer M & Berg P.1991. *Genes and Genomes*. John Wiley & Sons.
- Hartl DL & Jones EW. 1998. *Genetics Principles and Analysis*. Jones & Barlett Publ.
- Micklos DA & Freyer G. 2003. *DNA Science - A First Course*. CPL Scientific Publ.
- Brooker RJ. 2004. *Genetics Analysis and Principles*. Addison-Wesley Longman.
- Watson JD. 2004. *Molecular Bilology of the Gene*. Pearson Edu.

PAPER – 204:EXPERIMENTAL DESIGNS

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 involving one-way and two way elimination of heterogeneity and their characterization properties. This course would also prepare the students in deriving the expressions for analysis of experimental data.

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; 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.

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.

PRACTICAL

THIRD SEMESTER

PAPER – 301:BIOTECHNOLOGY FOR CROP IMPROVEMENT

Objective : -To impart knowledge and practical skills to use biotechnological tools in crop improvement.

UNIT I

Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding.

UNIT II

Tissue culture- History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.

UNIT III

Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Vectors, vector preparation and cloning, Biochemical and Molecular markers: morphological, biochemical and DNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.), mapping populations (F2s, back crosses, RILs, NILs and DH).

UNIT IV

Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding.

UNIT V

Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression, Generation of EDVs.

UNIT VI

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, Biotechnology applications in male sterility/hybrid breeding, molecular farming. Nanotechnology and its applications in crop improvement programmes.

Practical

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants ;observations on the contaminants occurring in media – interpretations - Inoculation of explants; Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial micro-propagation unit. Transformation using *Agro-bacterium* strains, GUS assay in transformed cells / tissues. DNA isolation, DNA purity and quantification tests, gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship, construction of genetic linkage maps using computer software.

Suggested Readings

• Chopra VL & Nasim A. 1990. *Genetic Engineering and Biotechnology: Concepts. Methods and Applications*. Oxford & IBH.

• Gupta PK. 1997. *Elements of Biotechnology*. Rastogi Publ.

• Hackett PB, Fuchs JA & Messing JW. 1988. *An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation.* 2nd Ed. Benjamin Publ. Co.

• Sambrook J & Russel D. 2001. *Molecular Cloning* - a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.

• Singh BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani.

PAPER – 302:BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE

Objective : -To apprise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance andmethods to breed stress resistant varieties.

UNIT I

Importance of plant breeding with special reference to biotic and abioticstress resistance; Classification of biotic stresses – major pests and diseases of economically important crops - Concepts in insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR);

UNIT II

Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants. Quantitative resistance/Adult planresistance and Slow rusting resistance - Classical and molecular breeding methods - Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies.

UNIT III

Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications.

UNIT IV

Classification of abiotic stresses - Stress inducing factors –moisture stress/drought and water logging & submergence; Acidity, salinity/alkalinity/sodicity; High/low temperature,wind, etc.

Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

UNIT V

Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging & submergence, high and low/freezing temperatures; Utilizing MAS procedures fidentifying resistant types in important crops like rice, sorghum, wheat, cotton etc

UNIT VI

Exploitation of wild relatives as a source of resistance to biotic and abiotic factors in major field crops - Transgenics in management of biotic and abiotic stresses, use of toxins,protease inhibitors, lectins, chitnases and Bt for diseases and insect pest management-Achievements.

Practical

Phenotypic screening techniques for sucking pests and chewing pests – Traits to be observed at plant and insect level - Phenotypic screen techniques for nematodes and borers; Ways of combating them; Breeding strategies - Weeds – ecological, environmental impacts on the crops; Breeding for herbicide resistance - Evaluating the available populations like RIL, NIL etc. for pest resistance; Use of standard MAS procedures Phenotypic screening methods for diseases caused by fungi and bacteria; Symptoms and data recording; use of MAS procedures - Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation - Screening crops for drought and flood resistance; factors to be considered and breeding strategies - Screening varieties of major crops for acidity and alkalinity- their effects and breeding strategy Understanding the climatological parameters and predisposal of biotic and abiotic stress factors- ways of combating them.

Suggested Readings

• Blum A. 1988. *Plant Breeding for Stress Environments*. CRC Press.

• Christiansen MN & Lewis CF. 1982. *Breeding Plants for Less Favourable Environments*. Wiley International.

• Fritz RS & Simms EL. (Eds.). 1992. *Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics*. The University of Chicago Press.

• Li PH & Sakai A. 1987. *Plant Cold Hardiness*. Liss, New York

• Luginpill P. 1969. *Developing Resistant Plants - The Ideal Method of Controlling Insects*. USDA, ARS, Washington DC.

• Maxwell FG & Jennings PR. (Eds.). 1980. *Breeding Plants Resistant to Insects*. John Wiley & Sons.

• Painter RH. 1951. *Insect Resistance in Crop Plants*. MacMillan, New York.

• Russel GE. 1978. *Plant Breeding for Pest and Disease Resistance*. Butterworths.

• Sakai A & Larcher W. 1987. *Frost Survival in Plants*. Springer-Verlag.

• Turener NC & Kramer PJ. 1980. *Adaptation of Plants to Water and High Temperature Stress*. John Wiley & Sons.

• Van der Plank JE. 1982. *Host-Pathogen Interactions in Plant Disease*. Academic Press.

PAPER – 303:BREEDING CEREALS, SUGARCANE, LEGUMES, OILSEEDS AND FIBRE CROPS

Objective : -To provide insight into recent advances in improvement of cereals and forage crops,sugarcane legumes, oilseeds and fibre crops using conventional and modern biotechnological approaches.

UNIT I

Rice: Evolution and distribution of species and forms - wild relatives and germplasm;Genetics – cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc.*– Hybrid rice breeding- potential and outcome - Aerobic rice, its implications and drought resistance breeding.

UNIT II

Wheat: Evolution and distribution of species and forms - wild relatives and germplasm; cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance, exploitation of heterosis etc; Sorghum: Evolution and distribution of species and forms - wild relatives and germplasm - cytogenetics and genome relationship - Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc;

UNIT III

Maize: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance etc - QPM and Bt maize – strategies and implications - Heterosis breeding attempts taken in Sorghum, Pearl Millet and Maize; Minor millets:

UNIT IV

Sugarcane: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc - Forage grasses:

UNIT V

Forage legumes: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress resistance etc - Tree fodders: Evolution and distribution of species and forms;

UNIT VI

Distinguishing features of popular released varieties in Rice and Sorghum - Wheat, Pearl millet, Maize and other millets - Sugarcane, forage grasses and legumes and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production.

Practical

• Floral biology – emasculation - pollination techniques ; Study of range of variation for yield and yield components – Study of segregating populations and theirevaluation - Trait based screening for stress resistance in crops of importance– Use of descriptors for cataloguing Germplasm maintenance; learning on the Standard Evaluation System (SES) and descriptors; Use of softwares for database management and retrieval.Practical learning on the cultivation of fodder crop species on sewage water; analysing them for yield components and palatability; Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes;

Suggested Readings

• Agarwal RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.
• Bahl PN & Salimath PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I. *Pulses and Oilseeds*. Oxford & IBH.
• Chandraratna MF. 1964. *Genetics and Breeding of Rice*. Longmans.
• Chopra VL & Prakash S. 2002. *Evolution and Adaptation of Cereal Crops*. Oxford & IBH.
• Gill KS. 1991. *Pearl Millet and its Improvement*. ICAR.
• IRRI. 1964. *Rice Genetics and Cytogenetics*. Elsevier.
• IRRI. 1986. *Rice Genetics*. Proc. International Rice Genetics Symposium.
• IRRI, Los Banos, Manila, Philippines.
• IRRI. 1991. *Rice Genetics II*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
• IRRI. 1996. *Rice Genetics III*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
• IRRI. 2000. *Rice Genetics IV*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
• Jennings PR, Coffman WR & Kauffman HE. 1979. *Rice Improvement*. IRRI, Los Banos, Manila, Philippines.
• Kannaiyan S, Uthamasamy S, Theodore RK & Palaniswamy S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*.
• Directorate of Extension Education, TNAU, Coimbatore. Murty DS, Tabo R & Ajayi O. 1994. *Sorghum Hybrid Seed Production and Management*. ICRISAT, Patancheru, India.
• Nanda JS. 1997. *Manual on Rice Breeding*. Kalyani.
• Ram HH & Singh HG. 1993. *Crop Breeding and Genetics*. Kalyani.
• Singh HG, Mishra SN, Singh TB, Ram HH & Singh DP. (Eds.). 1994.
• *Crop Breeding in India*. International Book Distributing Co. Slafer GA. (Ed.). 1994. *Genetic Improvement of Field Crops*. Marcel Dekker.
• Smartt J. 1994. *The Groundnut Crop - a Scientific Basis for Improvement*. Chapman & Hall.

PAPER – 304: HETEROSIS BREEDING

Objective : -To provide understanding about mechanisms of heterosis and its exploitation for yield improvement through conventional and biotechnological approaches.

UNIT I

Historical aspect of heterosis - Nomenclature and definitions of heterosis - Heterosis in natural population and inbred population; Evolutionary aspects - Genetic consequences of selfing and 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, frequency of inbreeding and residual heterosis in F2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies. - Relationship between genetic

distance and expression of heterosis – case studies; Divergence and Genetic Distance analyses-morphological and molecular genetic distance in predicting heterosis.

UNIT IV

Fixation of heterosis in self, cross and often cross pollinated crops, asexually/clonally propagated crops; Male sterile line creation and diversification in self pollinated, cross pollinated and asexually propagated crops; problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid.

UNIT V

Organellar heterosis and complementation - Creation of male sterility through genetic engineering and its exploitation in heterosis.Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops.

Practical

Selection indices and selection differential – Calculations and interpretations - Male sterile line characterization in millets; Using morphological descriptors; Restorer line identification and diversification of male sterile sources - Male sterile line creation in dicots comprising oilseeds, pulses and cotton ; problems in creation of CGMS system; Ways of overcoming them - Male sterile line creation, diversification and restoration in forage crops;Understanding the difficulties in breeding apomicts; Estimation of heterotic parameters in self, cross and asexually propagated crops - Estimation from the various models for heterosis parameters - Hybrid seed production in field crops – an account on the released hybrids; their potential; Problems and ways of overcoming it; hybrid breeding at National and International level; Opportunities ahead.

Suggested Readings

- Proceedings of *Genetics and Exploitation of Heterosis in Crops* - An International 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. Anmol Publ.

FOURTH SEMESTER

COURSE CONTENTS – DETAILED SYLLABUS

PAPER – 401: MAINTENANCE BREEDING AND CONCEPTS OF VARIETY RELEASE AND SEED PRODUCTION

Objective : -To apprise the students about the variety deterioration and steps to maintain the purityof varieties & hybrids and principles of seed production in self & cross pollinated crops.

UNIT I

Variety Development and Maintenance; Definition- variety, cultivar, extant variety,essentially derived variety, independently derived variety, reference variety, farmers' variety, hybrid,and population; Variety testing, release and notification systems in India and abroad.

UNIT II

DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding.

UNIT III

Factors responsible for genetic deterioration of varieties - safeguards during seed production; Maintenance of varieties in self and cross-pollination crops- isolation distance;Principles of seed production; Methods of nucleus and breeder seed production.

UNIT IV

Generation system of seed multiplication -nucleus, breeders, foundation, certified, -
Quality seed production technology of self and cross-pollinated crop varieties viz. cereals & millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi etc.);

UNIT V

Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton, jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne

Practical

Identification of suitable areas/locations for seed production; Ear-to-row method and nucleus seed production - Main characteristics of released and notified varieties, hybrids and parental lines; Identification of important weeds/objectionable weeds; Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties in different crops; Hybrid seed production technology of important crops.

Suggested Readings

- Agarwal RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.
- Chhabra AK. 2006. *Practical Manual of Floral Biology of Crop Plants*. Department of Plant Breeding. CCS HAU Hisar.
- Kelly AF. 1988. *Seed Production of Agricultural Crops*. Longman.
- McDonald MB Jr & Copeland LO. 1997. *Seed Production: Principles andPractices*. Chapman & Hall.
- Musil AF. 1967. *Identification of Crop and Weed Seeds*. Handbook No.219, USDA, Washington, DC.
- Poehlman JM & Borthakur D. 1969. *Breeding Asian Field Crops*. Oxford & IBH.
- Singh BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani.
- Thompson JR. 1979. *An Introduction to Seed Technology*. Leonard Hill.
- Tunwar NS & Singh SV. 1985. *Handbook of Cultivars*. ICAR.

PAPER – 402:CONSERVATION & UTILIZATION OF PLANT GENETICS RESOURCES

Objective : -To provide information about collection, germplasm exchange, quarantine, maintenance and use of plant genetic resources including geneticallymodified plants.

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 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;

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, postentry 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 bio-safety, 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 bio-safety.

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 plantin 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.

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 ofAchievements*. 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.
• Painting KA, Perry MC, Denning RA & Ayad WG. 1993. *Guide Book forGenetic Resources Documentation*. IPGRI, Rome, Italy.
• Puzone L & Th. Hazekamp 1996. *Characterization and Documentation of Genetic Resources Utilizing Multimedia Database*. NBPGR, New Delhi.
• Rana RS, Sapra RL, Agrawal RC & Gambhir R. 1991. *Plant Genetic Resources, Documentation and Information Management*. NBPGR, New Delhi.

FOURTH SEMESTER

PAPER – 403:SEMINAR
M.Sc. (AGRICULTURE) PLANT BREEDING & GENETICS
FOURTH SEMESTER
COURSE CONTENTS – DETAILED SYLLABUS
OPTIONAL PAPER – 404
PAPER – 404 (A)
THESIS (THESIS AND VIVA – VOCE)
OR
PAPER – 404 (B)
SPECIAL PAPER (PLANT BREEDING PRESPECTIVE)

PAPER – 404 (A)
THESIS (THESIS AND VIVA – VOCE)
Suggested Broad Topics for ResearchWork

 Studies on introgressions, gene transfers, gene identification, location and localization with the application of technologies such as, *in situ* hybridization,chromosome identification like FISH (Fluorescent *In Situ* Hybridization), GISH (Genomic *In Situ* Hybridization), Spectral Karyotyping (SKY) and Multiplex Fluorescence *In Situ* Hybridization (M-FISH) etc. Studies on stay-green traits in relation to genes affecting efficiency of photosynthethesis, biotic/abiotic stress tolerance Genetics of AGP system for better photosynthesis and translocation Identification of genes/QTLs for NUE and WUE Molecular markers tagged to genes/QTLs identified for improvement of nutrient use efficiency, water use efficiency Relative efficiency analyses of genetic component estimation for reliable use in developing selection criteria in crop plants Distance and divergence statistics for identification of similarity assessment among genetic stocks and parental genetic material Linear and quadratic distance measures to identify relative contribution of component traits for complex traits Studies on genetic and molecular

bases of stress tolerance to develop molecular diagnostics for screening/identification of stress tolerant genotypes . Use of aneuploids for gene location and source for transfer through wild species.

Development and trisomic and monosomic series in diploids and polyploids

Dependable marker systems for detection of introgression in wide crosses with minimized linkage drag

Analysis of Resistance Gene analogues and their use in MAS with enhanced disease resistance

Analysis of Gene analogues and expression synteny and their use in MAS with enhanced quality and trait expression

Refinements in embryo rescue and consequent diplodization for production of double haploids

Use of molecular markers in phylogenetic analysis

Breeding through distant hybridization route for New Plant Type for breaking yield barriers

Genetics of durable, quantitative resistance and adult plant resistance in major crops against known pathogens

Development of tools and methodologies for identification of genes responsible for resistance against polyphagus insects

Development of alien addition lines and telocentric lines in crops

Microarray technique and robotics for identification of useful genes in crops

Characterization of germplasm through molecular and serological techniques

Induction of novel variation through mutagenesis tools and identify novel genes for different traits

Development of heterotic pools for maximized heterosis in cross and self pollinated crops where hybrid seed production tools are available

Genetics and traits responsible for terminal and initial heat tolerance in wheat, maize and mustard

Genetics of cold tolerance related traits in maize, rice and pigeonpea

Widening the QPM base in maize and prebreeding to add value to the genetic stocks of QPM

Comparison of relative efficiency of different softwares in analysis of quantitative trait loci and linkages

Biochemical and molecular bases of signal transduction in host-pathogen interactions

Metal binding proteins for identification of phytoremediators

Crop improvement for biomass energy and industrial use

Development of cytogenetic stocks through varietal/alien chromosome substitutions

M.Sc. (AGRICULTURE) PLANT BREEDING & GENETICS

FOURTH SEMESTER

COURSE CONTENTS – DETAILED SYLLABUS

PAPER – 404 (B)

SPECIAL PAPER (PLANT BREEDING PRESPECTIVE)

UNIT 1

Plant Breeding – Historical Perspective:

Earliest steps in Plant Breeding, Plant Breeding following hybridization, Plant Breeding

developments before 1900, Plants Breeding after 1900, Goals of Plant Breeding, recent trends in Plant Breeding, Eminent of Plant Breeding.

UNIT 2

Modes of Reproduction in relation to Plant Breeding:

Mode of Reproduction in crop Plants, Flowering biology, Sporogenesis, Anthesis, Fertilization, Mechanism of pollution control, determination of pollution system and relevance of mode of reproduction to Plant Breeding.

UNIT 3

Breeding Techniques applicable in the Future:

Current Breeding Methods, F1 hybrids, Apomixis, Breeding for stability of Yield, Resistance Breeding, Haploids, Polyploids and Wide crosses, DNA transfer, converting C3 plants into C4 plants, Adapting crops to new Environments, Breeding nutritionally balanced varieties.

UNIT 4

Organizations for Crop Improvement in India and International Institutions:

Cooperative researches and release of variety, All India coordinated research projects, International Collaborations in Plant Breeding.

UNIT 5

Cultivar Release, Seed Certification & Multiplication and Property Protection:

Cultivar Licensing, Breeder Seed, Multiplication from Breeder Seed, Seed Certification, Plant Breeder's Right.

PRACTICAL

1. Study of Taxonomy and Floral Biology of Cereal, Pulse, Oilseed and Fiber Crops.
2. Study of the technique of Hybridization and Selection in field important Cereal, Pulse, Oilseed and Fiber Crops.
3. Study of Seed Certification procedures in field in important Cereal, Pulse, Oilseeds and Fiber Crops.
4. A visit to Plant Breeding Experimental Research Station.
5. Presentation of Practical record, Charts, Models, etc.

M.Sc. (AGRICULTURE) PLANT BREEDING & GENETICS

FOURTH SEMESTER

COURSE CONTENTS – DETAILED SYLLABUS

PAPER – 405

PRACTICAL

PLANT BREEDING & GENETICS

List of Journals

- Australian Journal of Biological Sciences, Australia
- Australian Journal of Agricultural Research, Australia
- Biometrics, UK
- Bio-Techniques
- Cereal Research Communication, Hungary
- Cotton Research and Development, Hisar, India
- Crop Improvement, Ludhiana, India
- Crop Science, USA
- Current Science, Bangalore, India
- Critical Reviews in Plant Sciences
- Czech Journal of Plant Breeding Genetics, Prague,

- Electronic Journal of Biotechnology
- Euphytica, The Netherlands
- FABIS Newsletter
- Forage Research, Hisar, India
- Genetics, USA
- Genome, Canada
- Genetic resources and crop evolution, Netherlands
- Haryana Agricultural University Journal of Research, Hisar, India
- Heredity
- Hilgardia, Sweden,
- Indian Journal of Agricultural Research, New Delhi
- Indian Journal of Genetics and Plant Breeding, New Delhi
- Indian Journal of Plant Genetic Resources, New Delhi
- International Chickpea Newsletter, ICRISAT
- International Rice Research Notes, IRRI, Philippines
- Journal of Agricultural Research, U.K.
- Journal of Biochemistry and Biotechnology, New Delhi , India
- Journal of Genetics and Breeding, Italy
- Journal of Heredity
- Journal of Pulses Research, Kanpur, India
- Legume Research, Karnal, India
- MILWAI Newsletter
- Madras Agricultural Journal, Coimbatore, India
- Molecular Breeding, USA
- Mutation Research
- National Journal of Plant Sciences, Hisar, India
- Nucleic Acids Research, USA
- Oryza, Cuttack, India
- PGR Newsletter, Syria
- Plant Breeding, Germany
- Plant Molecular Biology, The Netherlands
- Rachis, Syria
- Sorghum and Millet Newsletter, ICRISAT
- Theoretical and Applied Genetics, Germany
- Wheat Research,

M.Sc. (AGRICULTURE)
PLANTS BREEDING & GENETICS
SEMESTER SYSTEM

M.Sc. (Agriculture) – PLANT BREEDING & GENETICS

In the area of Plant Breeding & Genetics an effort has been made to retain relevant core concepts and principles of Plant Breeding & Genetics as such. However, new topics and also new courses have been added to infuse new blood in the area.

- All the courses have been designed/redesigned/updated as per present and future needs.
- New courses have been introduced to keep pace with the latest developments.
- In order to help the students, Course objectives and Suggested readings have

also been provided for each course.

• List of Journals have been provided to keep pace with latest developments in the area.

• Suggested Areas of Research have also been added for providing directions to future researches in the area

This programme also requires proper infrastructure, trained teachers, and computers with internet connections. Industrial linkages, guest lectures, industry and farm visits will also be required to provide real life exposure.

COURSE STRUCTURE – AT A GLANCE

FIRST SEMESTER M.M.: 500

PAPER – 101 PRINCIPLES OF GENETICS 100 MARKS
PAPER – 102 PRINCIPLES OF CYTOGENETICS 100 MARKS
PAPER – 103 PRINCIPLES OF PLANT BREEDING 100 MARKS
PAPER – 104 STATISTICAL METHODS 100 MARKS
PAPER – 105 PRACTICAL 100 MARKS

M.Sc. (Agriculture) – Plant Breeding & Genetics

COURSE STRUCTURE – AT A GLANCE

SECOND SEMESTER M.M.: 500

PAPER – 201 PRINCIPLES OF QUANTITATIVE GENETICS 100 MARKS
PAPER – 202 MUTAGENESIS AND MUTATION BREEDING 100 MARKS
PAPER – 203 CELL BIOLOGY AND MOLECULAR GENETICS 100 MARKS
PAPER – 204 EXPERIMENTAL DESIGNS 100 MARKS
PAPER – 205 PRACTICAL 100 MARKS

M.Sc. (Agriculture) – Plant Breeding & Genetics

COURSE STRUCTURE – AT A GLANCE

THIRD SEMESTER M.M.: 500

PAPER – 301 BIOTECHNOLOGY FOR CROP IMPROVEMENT 100 MARKS
PAPER – 302 BREEDING FOR BIOTIC AND ABIOTIC STRESS RESISTANCE 100 MARKS
PAPER – 303 BREEDING CEREALS, SUGARCANE 100 MARKS
LEGUMES, OILSEEDS AND FIBRE CROPS
PAPER – 304 HETEROSIS BREEDINGH 100 MARKS
PAPER – 305 PRACTICAL 100 MARKS

M.Sc. (Agriculture) – Plant Breeding & Genetics

COURSE STRUCTURE – AT A GLANCE

FOURTH SEMESTER M.M.: 500

PAPER – 401 MAINTENANCE BREEDING, CONCEPTS OF VARIETY RELEASE 100 MARKS
AND SEED PRODUCTION
PAPER – 402 CONSERVATION & UTILIZATION OF PLANT GENETICS 100 MARKS
RESOURCES
PAPER – 403 SEMINAR 100 MARKS
PAPER – 404 THESIS (THESIS AND VIVA – VOCE) / SPEICAL PAPER 100 MARKS
PAPER – 405 PRACTICAL 100 MARKS