Syllabus for M. Phil. Genetics and Plant Breeding

Theory Courses:  

1. Statistical Methods in Agricultural Research  
2. Mutation Research in Crop Improvement  
3. Molecular Cytogenetics & Molecular Breeding  
4. Genetics of Quantitative Traits  
5. Biometrical Methods in Plant Breeding  
6. Genetics and Breeding of Problem Traits in Some Crops

*Each theory course will have 100 maximum marks. For 80 marks, the evaluation will be conducted both by the internal and external examiners. The average of the marks given by the two examiners will be awarded out of 80 maximum marks. For the remaining 20 marks the evaluation will be conducted only by the internal examiner and the awarded marks will be added to the average marks awarded out of 80 marks.
M. Phil. (Genetics & Plant Breeding)

1. Statistical Methods in Agricultural Research

Teaching hours: 50

1. **Population and sample for statistical analysis**: Parameter and statistics; likelihood function; method of maximum likelihood estimation; sampling distribution of mean and standard error; estimation of population mean and its confidence interval in the normal case. 4

2. **Testing of hypothesis and significance tests**: Null and alternative hypothesis; types of error; levels of significance; tests of significance (z-test; t-test; F-test for testing the equality of two variances and homogeneity of means (analysis of variance); comparison of means by least significant difference, Duncan’s multiple range test, Student Newman Keul’s test, Tukey’s test; Chi-square test of goodness of fit, independence of attributes and homogeneity of samples, Bartlett’s test for homogeneity of variances). 10

3. **Probability distribution**: Binomial, poisson and normal distributions (without derivations); interrelations and simple properties of these distributions; fitting of above distributions and Ch-square test for their goodness of fit. 10

4. **Correlation and regression**: Multiple and partial correlation (for three variables only); multiple regressions; tests of significance for correlation coefficient and regression coefficient. 8

5. **Designs of experiments**: Completely randomized; randomized block and latin square designs and the related analysis of variance; missing plot technique in RBD; simple factorial experiments of the types $2^2$, $2^3$, $3^2$; compounding in factorial experiment; split plot and lattice design experiments. 18

**Suggested Readings**

2. Mutation Research in Crop Improvement

Teaching hours: 50

1. **Mutations**: Nature, occurrence and causes of mutations; types and classification of mutations; chromosomal aberrations vs. gene mutations; when to use mutations in plant breeding. 4

2. **Mutagens – properties and mode of action**: Physical vs. chemical mutagens; ionizing vs. non-ionizing radiations.
   (a) **Mutagenic radiations**: Types and sources; X-rays, γ-rays, β-rays, neutrons and UV rays; radiation biology; objects and methods of treatment; radiation sensitivity and modifying factors; methods of pre-and post-treatments. 8
   (b) **Chemical mutagens**: Main mutagenic compounds (alkylating agents, base analogues, azide, nitrous acid, acridines, hydroxylamine); mode of action; objects and method of treatment; dose and half life; modifying factors; methods of pre- and post treatment. 6

3. **Induced mutation techniques in breeding seed propagated crop species**: Selection of parents and handling of M₁ – M₃ generations for selection of mutants; detection of induced mutations; identification, evaluation and documentation of mutants; factors affecting the mutant spectrum and quality of mutants; case studies of how to breed improved crop cultivars by using induced mutations. 8

4. **Induced mutation techniques in breeding vegetatively propagated plants**: Breeding methods and selection of parents; mutagen treatment and handling of treated material; somaclonal variation and *in vitro* selection; cultivars developed through mutation induction. 2

5. **Plant characters to be improved by mutation breeding (with some case studies)**: Yielding ability; flowering and ripening time; adaptability; plant type and growth habit; resistance to lodging; tolerance to low temperature, drought, heat and salinity; disease and pest resistance; protein quality. 10

6. **Directed mutagenesis**: Possibility of inducing directed mutations using specific stages of cell division and mutagens; site directed mutagenesis. 2

7. **In vitro mutagenesis**: Induction of mutations through/in tissue cultures. 2

8. **Insertional mutagenesis**: Transposon mutagenesis, T-DNA mutagenesis. 2

9. **Role of induced mutations in allele mining and functional genomics**: TILLING (Targeting Induced Local Lesions In Genomes), Deleteagene™ approaches. 4
Suggested Readings:

3. Molecular Cytogenetics & Molecular Breeding

**Teaching hours: 50**

**Part I. Molecular Cytogenetics**

1. **Introduction**
2. **Chromosome sorting and microdissection**: Measurement of nuclear DNA content; AT: GC measurement, principle of sorting chromosomes through flow cytometry; flow karyotyping and chromosome sorting; development of chromosome and chromosome arm specific libraries.

3. **In situ hybridization (ISH) and its applications**: ISH, FISH, GISH, McFISH, Fibre FISH, BAC FISH; physical mapping of DNA sequences; genome analysis; detection of alien introgressed sequences/segments.

4. **Molecular markers**: A brief idea of different types of markers (RFLP, STS, SSR, AFLP including its variations (such as SAMPL, MFLP, etc.), Single Nucleotide Polymorphisms (SNPs), DArT markers, etc., markers from functional portion of the genome (such as ESTPs, EST-SSRs, EST-SNPs), methods of their development and use.

5. **Genetic, cytogenetic and physical maps using molecular markers**: Methods of preparation of genetic and cytogenetic maps; physical maps using deletions, ISH, BACs; chromosome walking and jumping.

**Part II. Molecular Breeding**

6. **Methods of gene transfer in plants**: Agrobacterium mediated gene transfer, direct DNA delivery methods (microinjection, particle gun method and electroporation), gene targeting (Zink finger nucleases)

7. **Transgenics for crop improvement**: Utility of transgenics for improvement of input and output traits (resistance to biotic and abiotic stresses; barnase and barstar for hybrid seed production); biosafety issues including risks associated with transgenic crops; biosafety regulations.

8. **Molecular marker assisted selection (MAS) and its applications**: Selection of traits and markers for MAS; effectiveness and efficiency of MAS over phenotypic selection; marker-assisted backcross breeding and pyramiding; foreground and background selections; marker-assisted recurrent selection (MARS), genome-wide selection (GWS); epistasis in MAS; marker assisted hybrid (MAH) breeding; economics of MAS; important examples of successful MAS.

**Suggested Readings**

4. Genetics of Quantitative Traits

1. **History of the study of quantitative traits**: Simple and complex quantitative traits, multiple factor hypothesis, transition of the methods of studying quantitative traits over time.  
   
2. **Quantitative trait loci (QTL) and requisites for QTL mapping.**  
   
3. **QTL mapping**: Quantitative genetic models (single QTL model, multiple locus model), mixture model.  
   
4. **QTL mapping using single marker analysis**: Study of joint segregation of QTL and marker genotypes through Bulked Segregation Analysis (BSA), single marker QTL analysis (SMA) using linear regression and t-test, analysis of variance.  
   
5. **QTL interval mapping**: Maximum likelihood and regression approaches and their comparison for QTL analysis, expectation maximization algorithm, joint segregation of QTL and marker genotypes, simple interval mapping (SIM) and composite interval mapping (CIM), multiple trait mapping (multiple trait simple interval mapping and multiple trait composite interval mapping), advantages of CIM over SMA and SIM.  
   
6. **Epistatic QTLs and QTL × environment interaction**: Epistatic QTLs with and without main effects, QTL × environment interaction.  
   
7. **Genetical genomics and e-QTLs**: Expression profile and its genetic control.  
   
8. **Bayesian approach for QTL mapping**: Introduction, Bayes’ theorem, simple and conditional probabilities, advantages of Bayesian analysis.  
   
9. **High resolution mapping and cloning of QTLs**: Population size, molecular markers (markers from targeted region, mapped markers from orthologous regions), strategies for high resolution mapping using BSA and near isogenic lines (NILs).  
   
10. **Linkage disequilibrium (LD)**: Introduction, measures of LD, factors affecting LD, LD and QTL mapping in plants.  
   
11. **Admixture mapping**  
   
12. **QTL analysis for plant breeding and population/evolutionary genetic studies**
13. Computer tools: Softwares for linkage analysis and map construction, softwares for QTL mapping

Suggested Readings:

5. Biometrical Methods in Plant Breeding

Teaching hours: 50

1. **Quantitative inheritance**: Multiple factor hypothesis; polygene concept; nature of quantitative inheritance; genetics of polygenetic traits. 2

2. **Variation**: Source of variation and partitioning of components of variance. 2

3. **Components of generation means**: Six, five and three parameters models; scaling test, joint scaling test, linkage and genotype x environment interactions. 6

4. **Combining ability analyses and gene effects**: General combining ability; specific combining ability; additive, dominance and epistatic gene effects; line x tester analysis; diallel analysis, graphical and component analysis of Hayman’s approach; combining ability variances and effects, Griffing’s approach; partial diallel cross analysis; elementary idea of triallel cross analysis, North Carolina design, triple test cross analysis. 14

5. **Stability and adaptability**: Parametric and non–parametric approaches.
   - Parametric approaches: (i) Statistical models– Finlay and Wilkinson’s approach and Eberhart and Russell approach; biometrical models–Perkins and Jink’s approach, Freemann and Perkin’s approach; (ii) Additive x environment and dominance x environment interaction.
   - Nonparametric approaches: Clustering of genotypes based on environmental performance. 14

6. **Character association**: Genotypic and phenotypic correlation coefficients; path analysis and their utility in plant breeding. 4

7. **D² statistics**: Elementary idea. 4

8. **Discriminant function and selection indices.** 2

**Suggested Readings:**

6. Genetics and Breeding for Specific Traits in Some Crops

1. Detailed study of the following crops with their introduction, major problem traits and their genetics, and national and international germplasm enhancement and breeding efforts for improvement.

(a) Wheat: Protein content and its composition, milling and baking quality, abiotic stresses (terminal heat tolerance, metal tolerance, drought tolerance), biotic stresses (head blight, Karnal bunt, aphid resistance), water and fertilizer (N, P, K) use efficiency.

(b) Rice: Grain quality traits, biofortification for β-carotene, iron and Zn content, submergence tolerance, water-stress tolerance including rice for arid zones, terminal low temperature tolerance, resistance to herbicides, resistance to sheath blight and yellow stem borer, breeding for rice-wheat rotation

(c) Sugarcane: Development of co-canes (elite clones), fluff supply program, breeding for efficient ratooning, breeding for insect and pest resistance (borers, wilt and red rot), low temperature tolerance for ratooning, high sugar content; post harvest heat tolerance

(d) Potato: Breeding for true potato seed (TPS) for specific areas, chips quality, problem of sweetening in cold storage, frost tolerance, tolerance to leaf roll virus and late blight

(e) Rapeseed and mustard: Breeding for double zero varieties, oil quality improvement including PUFA (polyunsaturated fatty acids), tolerance to aphids, Alternaria.

(f) Pigeonpea: Breeding for resistance to sterility mosaic and Heliothis, exploitation of heterosis and breeding hybrid varieties, use of Atylosia as a source of novel genes.

2. Intellectual property rights and plant breeding.

Suggested Readings:

Subject: M.Sc. Ag. and M.Phil syllabi of Genetics & Plant Breeding.

Dear Professor Sanjeev,

With reference to above, please find attached the syllabi of our M.Sc. Ag. and M.Phil. courses in Genetics & Plant Breeding (both in hard copy as well CD).

Kindly acknowledge the receipt.

With regards.

Your sincerely,

(B. Ramesh)
Professor & Head

Encl.: as above
CERTIFICATE

It is certified that Mr./Ms.………………………………………..S/o or D/o…………………………….. bearing Roll No. …………………belonging to General/OBC/SC/ST category has qualified the Research Eligibility Test-2010 in…………………………………… conducted by Ch. Charan Singh University, Meerut (U.P.).

(H.S.Balyan)         (Prabhat Ranjan)
Coordinator RET-2010       Registrar